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MDCCCL.

Notes on the Influence exercised by Trees on Climate.

In 1847 the Court of Directors sent a despatch to the Supreme Government, requesting the attention of the authorities to the effect of trees on the climate and productiveness of a country or district. On receiving this communication the Madras Government directed a circular to their revenue officers requesting them to forward any of the required information in their power, and several valuable reports have accordingly been received in reply. Three of these having been placed at the disposal of the Literary Society, for publication in their Journal, the first inserted is a paper by Assistant Surgeon Balfour, whose attention having been directed to this subject for many years past, his own observations will be found interspersed with the remarks of different authors, the whole forming a summary of all that is known regarding this very important subject. Our thanks are due to Mr. Balfour for the valuable precis he has given and for the many well authenticated facts he has furnished, and although there is necessarily much in these notes that is speculative, and requiring further investigation, yet, with this paper before them, future inquirers will be able to prosecute their labours with all the exactness that a scientific inquiry of such vast importance to India, demands. That the subject will now be fully investigated there can be no doubt, for besides an interesting letter received from Surgeon Smith, a very important one has also been received from General Cullen, whose well known scientific character is sufficiently appreciated to ensure the attentive perusal of any remarks that proceed from his pen. General Cullen's observations and the report by Surgeon C. J. Smith of the Mysore Commission, likewise appear in this number of the Journal. EDS.

REVENUE DEPARTMENT.

No. 981.

Extract from the Minutes of Consultation under date the 8th September, 1848.

Read the following letter from Assistant Surgeon Edward Balfour.

From Assistant Surgeon EDWARD BALFOUR, *Madras Army.*

To The Secretary to Government.

SIR,—In the *Madras Spectator* of the 13th Instant it is mentioned that a despatch from the Court of Directors had reached the Supreme Government and been communicated to the Government of Madras on the subject of the effect produced by the presence of trees, whether as natural wood or the result of arboriculture, upon the climate and productiveness of any country, but more especially of India.

2d. A remark in one of Dr. Priestly's writings had directed my attention to the influence of trees on the health of man, and in the course of my inquiries, some years ago, I think in 1840, I arranged a few notes which I had collected on a collateral subject, viz.: the influence of trees in inducing rain and preserving moisture.

3d. These notes were published as an editorial article, to which the Editor prefixed the following paragraph.

"The following precis on the value and advantages of trees, their causing rain to fall in the districts where they grow, &c. will no doubt be read with pleasure by those who take an interest in the agricultural prosperity of India. The subject is one of great and general interest in any country, but, more particularly so in a country like this, where irrigation is of such paramount importance, involving the comfort and even existence of millions of our fellow creatures."

4th. This commendatory paragraph from the scientific and learned Editor makes me hope, that, at this time, when information is sought for, these notes may be accepted by the Government and may be deemed not unworthy of being added, or of forming a preamble to the information which they may be able to collect from other servants of this presidency.

I have the honor to be, &c.

KURNOOL, 31*st March*, 1848.

EDWARD BALFOUR, Asst. Surgn. *Madras Army.*

II. *Notes on the Influence exercised by Trees in inducing Rain and preserving Moisture: arranged by Assistant Surgeon* Edward Balfour, *Madras Army.*

With the exception of a few localities in Southern India the whole country seems destitute of trees. Whether they have disappeared under the hands of man while none were planted to supply their places, or whether they never existed, nothing so much strikes the attention as their general scarcity.

Having passed over a large part of the peninsula this bareness reminded me of the great influence that trees are believed to exercise on the composition of the atmosphere and on the quantity of water that falls on the earth's surface, and impressed with the belief that no small benefit would accrue to the country, and to the Government, were trees planted in particular localities, along roads and on lands which from their height or other causes cannot be brought under cultivation, I thought it might be useful to arrange the meteorological facts bearing on this point that have been recorded by different observers; for if a candid examination of these facts lead us to acknowledge their correctness, we cannot but look upon the cultivation of trees as of vital importance in such a country as India, where, under a tropical sun, the atmosphere is so likely to become loaded with miasmata and the fertility of the land is so much dependent on the supply of water.

Aware of the great falls of rain, which in several parts of India amount to 120 inches during the year, it might at first sight appear inexplicable to us when informed of the very limited quantity that other places receive; and, amongst others, "that less rain falls at Bellary than at any other place in Southern India, for during the year 1838 only 11¼ inches fell." But our surprise diminishes on learning "that towards the centre of the Ceded Districts the surface of the plain presents a monotonous and almost treeless aspect bounded by the horizon, and unbroken save by a few rocky elevations that stand forth abruptly from the sheet of black soil like rocks from the ocean. The country from Bellary to Tarputtry and from Pennacoondah, Ghooty and Adoni to the Kistnah is much of a similar nature. Sir Thomas Munro might

well observe that these districts are more destitute of trees than any part of Scotland he ever saw, and that the traveller scarcely meets with one in fifty miles and no where with a clump of fifty.* In Bellary the heat and glare are excessive.

Incidental remarks are met with in the writings of many authors showing how closely, from their observations, the purity, humidity and temperature of the atmosphere, and the supply of water on the earth's surface depend on the foliage of trees; and, indeed, I would have hesitated to have thrown these few notes together were the facts less numerous than we find them, or in any way doubtful, but we can form from many of them no other conclusion than that the abundant or scanty supply of rain depends on the number or scarcity of trees, and that the quantity of rain which falls alters as the trees are diminished or increased.

All who have travelled over a bare sandy tract in a tropical country and breathed the dry irritating air lying over it must remember the great relief experienced on gaining the shade of a clump of trees or even of a solitary tree, and it is easy for such travellers to understand the beneficial effect that the cooler air, there, must exert on the neighbouring vegetation.

Alluding to the unhealthiness of Hong Kong, Fortune, in his "Wanderings"† remarks that his own observations had led him to the following conclusions. Much of the sickness and mortality doubtless proceeded from the imperfect construction and dampness of the houses in which our people were obliged to live when the colony was first formed, and a great deal may be also attributed to the fierce and burning rays of the Hong Kong sun. All the travellers in the East with whom I had any conversation on the subject agreed that there was a fierceness and oppressiveness in the sun's rays, here, which they never experienced in any other parts of the tropics, even under the line; I have no doubt that this is caused by the want of luxuriant vegetation and the consequent reflection of the sun's rays. The bare and barren rocks and soil reflect every ray that strikes them; there are no trees or bushes to afford shade or to decompose the carbonic acid and ren-

* Captain Newbold in Madras Journal of Literature and Science, No. 24, p. 122.

† Fortune's Wanderings in China, 1847, p. 26.

der it fit for the respiration of man, and thus the air wants that peculiar softness which makes it so equable even in hot tropical climates.

If these are the principal causes of the mortality in our new colony the remedy will of course be apparent to every one. Already a great improvement has taken place in the houses of the merchants and in the barracks of the soldiers, and the results have been most satisfactory. But the colonists must not stop in this stage of their improvements. Let the Governor and the inhabitants use every means in their power to clothe the hill sides in and around the town with a healthy vegetation: let them plant trees and shrubs by the road sides, in gardens and in every place available for such purposes, and, then, I have no doubt, that Victoria will be quite as healthy as Macao. No one can approve of the selection of Hong Kong as a British settlement, but that part of the business being irremediable we must make the most of our bargain."

But perhaps no one, more beautifully than Humboldt, describes the arid dryness which the aspect of a tropical country presents when destitute of vegetation. After a descent of 1,000 feet from the valleys of Aragua had brought the travellers towards the Oronoko they "entered the basin of the Llanos in the Mesa de Paja in the 9th degree of latitude. The sun was almost at the zenith; the earth wherever it appeared sterile and destitute of vegetation was at the temperature of 48° or 50°. Not a breath of air was felt, yet, in the midst of this apparent calm, whirls of dust incessantly arose. All around us, says Humboldt, the plains seemed to ascend toward the sky and that vast and profound solitude appeared to our eyes like an ocean covered with sea-weeds. The earth there was confounded with the sky, through the dry fog and strata of vapour, the trunks of palm trees were seen from afar; stripped of their foliage and their verdant summits, these trunks appeared like the masts of a ship discovered at the horizon.

There is something awful but sad and gloomy in the uniform aspect of these steppes. Every thing seems motionless; scarcely does a small cloud as it passes across the zenith and announces the approach of the rainy season, sometimes cast its shadow on

the Savannah. I know not whether the first aspect of the Llanos excites less astonishment than that of the chain of the Andes. It is impossible to cross these burning plains without inquiring whether they have always been in the same state: or whether they have been stripped of their vegetation by some revolution of nature. The natives believe that the palmares and the chaparales, (the little groves of palm trees and rhopala) were more frequent and more extensive before the arrival of the Spaniards. Since the Llanos have been inhabited and peopled with cattle, become wild, the Savannah is often set on fire to meliorate the pasturage, and groups of scattered trees beneath the shade of which vegetation enjoyed a protection from the scorching rays of the sun, are accidentally destroyed.*

St. Pierre tries to explain the mode in which trees temper the heat of tropical countries. One day in summer, he says, about the hour of two in the afternoon, being about to cross the forest of Ivry, I observed some shepherds with their flocks, who kept at a distance from it, reclining under the shade of the trees scattered over the country. I asked why they did not go into the forest, to shelter themselves and their flocks from the heat of the sun. They told me it was then too hot there and that they never drove their sheep thither but in the morning and evening. Being desirous, however, of traversing in broad day, the forest in which Henry IV. had hunted and of arriving betimes at Anet to view the country residence of Henry II. and the tomb of his mistress, Diana de Poictiers, I engaged a boy belonging to one of the shepherds to accompany me as a guide, which was a very easy matter to him as the road to Anet crosses the forest in a straight line and it is so little frequented that I found it covered in many places with grass and strawberry plants. I felt all the time I was walking a suffocating heat and much more intense than that experienced in the open country. I did not begin to breathe freely till I was quite clear of the forest and had proceeded more than three musket shots from its skirts.

I have since reflected on what the shepherds told me concerning the heat of the wood, and, on my own experience of the truth

* Personal Narrative, vol. iv., p. 291, et sequent.

of their information, and I have, in fact, remarked, that in spring, all the plants are more forward in the vicinity of woods and that violets are found in flower on their borders much earlier than in the open plain or on the naked hill. The forests, therefore, protect the ground from the cold in the north, but what is not a little wonderful, they shelter it from the heat in warm climates. These two opposite effects proceed only from the different forms and dispositions of their foliage. In the north the leaves of the pine, the larch, the fir, the cedar, and the juniper are slender, glossy and varnished; from their smallness, their polish, and the variety of their directions they reflect the heat around them in a thousand ways producing nearly the same effect as the hair of the animals of the north whose furs are warmer in proportion as their hair is more fine and glossy. Besides, the leaves of several species, as the fir and the birch, are suspended perpendicularly from their branches by long moveable stalks, so that with the least breath of wind, they reflect around them the rays of the sun, like mirrors. In the south, on the contrary, the palm, the talipot, the cocoa and the banana bear large leaves which on the side towards the ground are rather dull than glossy, and which extending horizontally, throw a broad shade beneath them, without any reflection of heat; I admit, nevertheless, that the clearing away of forests dispels the cold arising from humidity, but it increases the dry and piercing cold of the north, as experience has proved on the lofty mountains of Norway which were formerly cultivated, but are now uninhabitable because they have been totally stripped of their woods. This clearing of the ground likewise increases the heat in warm countries, as I have observed in the Isle of France on several hills, which, since all the trees have been destroyed, are become so dry as to be at present incapable of cultivation. The grass which grows on them during the rainy seasons, is in a short time burned by the sun. What is still worse, in consequence of the aridity of these hills a great number of streams are dried up: for trees planted on eminences attract the humidity of the air and fix it there, as we shall see in the study that treats of plants. Besides, by destroying the trees which are on high grounds, the vallies are deprived of their natural manures, and the plains of the skreens which shelter them from the high winds. These are in some

places so destructive to cultivation, that nothing can be made to grow upon them. It is to this cause that I ascribe the sterility of the heaths of Brittany. In vain have attempts been made to restore them to their former fertility, they will never succeed, unless we begin with restoring to them their shelter and their temperature by replanting their forests.*

This effect of trees in mitigating the intensity of tropical heat has also been alluded to by the present superintendent of forests in our western presidency, who mentions that in the southern districts of Guzerat the vicinity of the sea and the proximity of the mountain tracts covered with jungle tend to render the climate more mild and the temperature throughout the year, more equable, than is the case in the other parts of the province. Farther inland and in the immediate vicinity of the hills the heat is greater, and in both situations the humid and loaded atmosphere in the S. W. monsoon, is often painfully felt particularly at night. In the whole of this district rain falls in greater quantities than to the northward; in the jungle districts to the east, the supply of rain is said never to fail in the driest of seasons and it often falls there when none is apparent in the more open districts.

It is in such tracts as these that rivers rise, for from the number, height, and comparative proximity of the hills, to the southward of the Taptee, we might a priori suppose that the supply of water in that district would be abundant: and such is actually the case as we find in a breadth of 50 miles, eight rivers, all containing water throughout the year. Reasoning from these facts we may also predicate the sort of country in which these rivers have their origin, viz., under-lying hilly tracts abounding in rich soil, highly retentive of moisture and rendered still more so by luxuriant jungle.†

An instance of the quantity of rain increasing from trees being planted is mentioned in a work, very recently published in St. Helena, in which it is recorded that the quantity of rain which falls on that island has greatly increased within the last fifty years. The writer, after remarking that the past year (1847) may be considered a good one for the farm and garden, notwith-

* St. Pierre's Studies of Nature, vol. i., p. 223, ed. 1846.

† Surgeon Gibson in Tr. Bomb. Med. and Phys. Soc. Journal, p. 37 and p. 4.

standing the severity and length of the winter, thus continues; indeed in some parts of the island, the crops in particular have been remarkably good, having had plenty of rain at the proper season. By comparing with each other the quantities of rain which have fallen during the last seven years, it will be seen how greatly the amount varies from year to year. Many years must therefore elapse before sufficient data can be obtained from which to deduce a correct average of the annual amount. The quantity is perhaps double of what it was in the beginning of the present century. The cause of this increase is doubtless the plantations of trees which have been formed since that period on the high grounds. These plantations appear to have performed another piece of good service to the island. Formerly heavy floods caused by sudden torrents of rain, were almost periodical and often very destructive. For the last nine or ten years none have occurred. If the cause of these rains was electrical disturbance, the trees may, by their conducting powers, have controlled the tendency.*

If possessed of the foregoing information, alone, doubts might arise as to whether the extent of vegetation in such countries were not rather the consequence than the cause of the abundance of water, but the observations of other scientific men support the belief that a mutual reaction goes on between these two physical agents, and that the presence of trees greatly adds to the supply of water and feeds the running streams; and that so soon as man, to supply his wants, has thinned or removed the trees which clothe the hill sides of the district he inhabits, the rain diminishes or rapidly runs off, its rivers dry up, and the previous fertility of its lands completely disappears. As an instance of the consequence of the hill sides being denuded, an intelligent officer has stated that when he first went to Dapoolie, the hills were clothed with trees and shrubs; they now show nothing but bare rock and earth black and red. The climate is, now, considerably hotter and drier, and streams which then ran in May are now dried up in December.†

Humboldt after leaving the town of Caraccas remarks that ma-

* St. Helena Almanac, 1848, p. 5.

† Surgeon Duncan in *Bombay Times*, 1839.

ny of the mountains of that name enter the region of the clouds, but the strata of primitive rocks dip at an angle of 70° or 80° and generally toward the north-west. In the interior of the province we meet with spaces of land two or three leagues square, quite destitute of springs. The sugar cane, indigo and coffee can grow only in places where running waters can be made to supply the artificial irrigations necessary during very dry weather. The first colonists very imprudently destroyed the forests. Evaporation is enormous on stony soil surrounded with rocks that radiate heat on every side. In the eighth and tenth degree of latitude, in regions where the clouds do not glide along the soil, many trees are stripped of their leaves in the months of January and February, not on account of the sinking of the temperature as in Europe, but because the air at this season, the farthest from that of rains, has nearly attained its maximum of dryness. The plants with very tough and glossy leaves alone resist this absence of humidity. Beneath the fine sky of the tropics the traveller is struck with the aspect, almost hibernal, of the country: but the freshest verdure again appears, when he has reached the banks of the Oronoko where another climate prevails, and the great forests preserve by their shade, a certain quantity of moisture in the soil which they shelter from the devouring ardour of the sun.*

By felling the trees, that cover the tops and sides of the mountains, men in every climate prepare at once two calamities for future generations; the want of fuel and a scarcity of water. Trees by the nature of their perspiration and the radiation from their leaves in a sky without clouds, surround themselves with an atmosphere constantly cold and misty. They affect the copiousness of springs, not, as was long believed by a peculiar attraction for the vapors diffused through the air, but, because, by sheltering the soil from the direct action of the sun they diminish the evaporation of the water produced by rain. When forests are destroyed, as they are every where in America by the European planters with an imprudent precipitation, the springs are entirely dried up or become less abundant. The beds of the rivers remaining dry during a part of the year, are converted into torrents whenever great rains fall on the heights. The sward and moss disappear-

* Personal Narrative, vol. iv., p. 62.

ing with the brushwood from the sides of the mountains, the waters falling in rain are no longer impeded in their course; and instead of slowly augmenting the level of the rivers by progressive filtration, they furrow during heavy showers the sides of the hills, bear down the loosened soil, and form those sudden inundations that devastate the country. Hence it results that the destruction of forests, the want of permanent springs, and the existence of torrents, are three phenomena closely connected together.*

In the collectorate comprizing the South Conkan, under Bombay, since this tract has been denuded of forest as it now has, from the pressure of population, to a great extent been, all the inhabitants concur in asserting that the springs have left the uplands, that the climate has become greatly drier, the seasons more uncertain and the land less fertile. I believe that this can be confirmed by the testimony of the late Collector Mr. Elphinstone, but indeed it is most apparent to a person travelling along that line of country, as I have just now been doing, mainly with the intention of remarking changes which have taken place in the interval of fifteen years, which period of time has elapsed since I visited that line of country before; I have also understood that effects of a similar kind have been experienced at the Neilgherry Hills. A change of climate similar to that, now, under contemplation is by no means limited in extent to the mere district in which the clearing has taken place, but its influence extends far inland. Take for example all the southern and western portion of the Dharwar Zillah. This fertile country abounds in moisture in so much that it has been, (though rather inaptly I think) compared to the valley of the Mississippi: at all events American upland cotton grows there which it will hardly do in other parts of the Bombay Presidency. I think it is not too much to say that much of this moisture depends on the wooded country forming its western border, and that with the complete removal of this the climate would greatly change. My own opinion is that in the Bombay Presidency some cause of this kind has had a great share in producing that irregularity of the rainy season which has of late years been so much complained

* Personal Narrative, vol. iv., p. 143.

of, as to diminished fertility of the soil from the removal of belts of wooded country; the rationale of this is most evident.*

The climate of Rio de Janiero has been very much modified by the clearing away of the forests in the neighbourhood. Previous to this the seasons could scarcely be divided into wet and dry as they are at present. Then rain fell nearly all the year round, and thunder storms were not only more frequent but more violent. So much has the moisture been reduced that the supply of water for the city has been considerably diminished, and the Government has in consequence forbidden the further destruction of the forests." Gardner's Travels in Brazils.

Another author remarks that the whole of the eastern front of the range (of mountains in Penang) has within a few years been denuded of its forests, and representations have been often made to the local authorities at Penang, urging the necessity of reserving the jungles, on the summits and higher slopes, but hitherto without effect. * * * But climate concerns the whole community and its protection from injury is one of the duties of Government. In Germany and France there are special laws and departments for the preservation and extension of forests.

It is not necessary to cite Humboldt or Boussingault to prove the great influence in tropical regions of forests, and, especially, of mountain forests, in attracting and condensing clouds, diminishing local temperature and increasing humidity. But if the forests had no other effect than to protect the clay soil of the mountains from the action of the sun's rays this alone ought to be sufficient to ensure their careful preservation. It is in this soil that the waters which supply all the streams of the island, and which percolate downward to the lower lands, are enclosed. These mountains are in fact great natural reservoirs, elevated in mid air and exposing the most extended surfaces possible, which are covered to a small depth with a sponge of porous decomposed rock for the absorption and retention of water. In ordinary seasons, when there is a considerable fall of rain, the importance of preventing the contents of these reservoirs from being dissipated may not be so obvious. But it may now be considered as a well established fact that the eastern Archipelago is subject to periodical droughts, although the

* Report from Dr. Gibson, dated 9th March, 1846.

laws of their recurrence are not yet ascertained. That such droughts, will again happen and are in fact in the settled course of nature admits of no question.

Nature when left to herself provides a compensatory influence in the dense leafy forests but if these are consigned to destruction every successive drought will prove more baneful than the preceding. Unless Government will reserve at least the steeper mountain tracts which are not adapted for permanent culture there is nothing visionary in the apprehension, for it has been realized in other localities, that in some prolonged drought after the naked sides of the hills have been exposed for a few weeks to the direct heat of the sun every stream in the island will be dried up and universal aridity ensue. The great extent to which the plain of the mainland of Penang has been shorn of its forests, would of itself produce an urgent necessity for a stop being at once put to a war with nature, which must entail severe calamities on the future. In those mountains in Greece which have been deprived of their forests the springs have disappeared. In other parts of the globe the same consequence has followed. The sultry atmosphere and dreadful droughts of the Cape de Verde Islands are owing to the destruction of the forests. In large districts in India climate and vegetation have rapidly deteriorated from a similar cause, and the Government having become fully impressed with the necessity of respecting the stubborn facts of nature every means have been used to arrest and remedy the mischief. Forests which had been so easily and thoughtlessly cut down have at great cost been restored.*

The above remarks having been obtained from the writings of men whose lives have been devoted to the study of nature and her works, and the facts adduced having been drawn from the greater portion of our globe, it appears impossible that any one could rise from their perusal without acknowledging that there is a general belief entertained that it is to the abundance or scarcity of trees to which we must attribute the copious or scanty supply of rain, and the tempering, in the tropics, of the fierceness of the solar rays. While this general belief, therefore, must be acknowledged, and the fact itself, perhaps, admitted, it may, nevertheless, be as

* Journal of the Indian Archipelago, vol. ii. p. 534.

yet impossible to explain the mode in which trees and forests thus exercise their influence. From the writings of the authors above quoted it would seem as if several agencies were at work, and that independent of the supposed electric action which the mountain forests give rise to and of the attracting and condensing apparatus which their leaves are likened to, they produce a spongy tenacious under-soil which they protect from the drying effect of the winds and sun's rays, and by this means cause the rain that falls to trickle slowly to the lower lands and keep up a constant supply of water in the streams; and it will have been evident also that the trees which clothe the mountain summits are regarded by other authors, as a vast condensing apparatus placed by nature on the elevated parts of the earth to distil the waters of the clouds which so constantly enshroud their heights. While we are as yet only learning the laws that regulate the development of electricity, and its action on the surrounding atmosphere we know how great an influence it exercises on vegetation, and it is not impossible that mountain forests will ultimately be proved to be great electric forces placed by nature for the purpose of promoting the fall of rain. The most agreeable of the writers on this subject is St. Pierre who traces in every forest, tree, and shrub, and in every leaf and branch evidence of wise and beneficent design, which he beautifully alludes to when describing "the elementary harmonies of plants with the water and the air by means of their leaves and of their fruits."*

When the author of nature resolved to crown with vegetables even the highest pinnacles of the earth, he first adapted the chains of the mountains to the basins of the seas, which were to supply them with vapors; to the courses of the winds which were to waft them thither, and to the different aspects of the sun from which they were to receive warmth. As soon as these harmonies were established between the elements, the clouds ascended from the ocean and dispersed over the most remote parts of the continents. They there diffused themselves in a thousand different forms, in fogs, in dews, in rains, in snows, in frosts. They distilled from the upper regions of the atmosphere in manners equally various; some in a calm air, like our spring showers, fell in perpen-

* St. Pierre, Studies of Nature. London, 1846, vol. ii. p. 23.

dicular drops, as if they had been poured through a sieve; others driven by violent winds, were hurled horizontally against the sides of the hills: others descended in torrents, like those which, nine months in the year inundate the island of Gorgona, situated in the heart of the torrid zone in the burning gulf of Panama. Some piled themselves in mountains of snow on the inaccessible summits of the Andes to cool by their waters the continent of South America and by their frigid atmosphere the vast Pacific Ocean. Lastly, mighty rivers flowed through regions in which it never rains and the Nile watered the plains of Egypt.

God then said "Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth." At the words of the Almighty the vegetables appeared with organs fitted to collect the blessings of heaven. The elm arose on the mountains that skirt the Tanais covered with leaves in the form of a tongue: the tufted box issued from the brow of the alps; and the thorny caper tree from the rocks of Africa, with leaves scooped out into spoons. The pines of the sandy mountains of Norway attracted the vapors floating in the air with their taper foliage, arranged like a hair pencil: the verbascum extended its broad leaves over the parched sands; and the fern presented on the hills, its fan shaped foliage to the rainy and horizontal winds. A multitude of other plants from the bosom of the rock, from beds of flint, nay even from marble incrustations, received the waters of heaven in cornets, in cups, in cruets. From the cedar of Lebanon to the violet that skirts the grove there was not one but what presented its ample bowl, or its diminutive cup, conformably to its necessities or its situation.

This adaptation of the leaves of the plants of elevated situations to receive the rain, is varied without end, but their character is in general perceptible not only in their concave forms, but likewise in a small hollow channel on the stalk by which they adhere to the branches. It is somewhat similar to that which nature has traced on the upper lip of man to receive the humours which descend from the brain. It may be observed in particular on the leaves of thistles, which delight in dry and sandy situations. They have besides collateral awnings to prevent the loss of any portion

of the water that falls from heaven; plants which grow in very hot and very dry situations sometimes have the entire stem and leaf transformed into a channel; such is the aloe of the island of Socotora at the entrance of the Red Sea or the prickly taper of the torrid zone. The aqueduct of the former is horizontal, and that of the latter perpendicular.

What has prevented botanists from remarking the relations that exist between the leaves of plants and the waters by which they are refreshed is that they see them every where nearly of the same form, in the vallies as on the eminences: but though the mountain plants exhibit foliage of every species of configuration it may be easily perceived from their aggregation in the form of hair pencils or of fans, from the contraction of the leaves or other equivalent marks, but principally from the aqueduct which I have just mentioned, that they are intended to receive the rain water. This aqueduct is traced on the stalk of the smallest leaves of mountain plants; it is by means of it that nature has rendered even the forms of aquatic plants susceptible of vegetation in the most parched situations. The reed for example, which is only a round full pipe that grows by the water-side, appears incapable of collecting any humidity in the air though it is well adapted to elevated situations by its capillacious form which like that of gramineous plants, presents nothing which the wind can lay hold of. In fact if you examine the different species of the rush that clothe the mountains in various parts of the world, such as that called *icho*, on the lofty mountains of Peru, which is the only vegetable that grows on some parts of them, and those that thrive in our climates in parched sands or on eminences, you would, at first sight, believe them to be similar to the rush of the marshes: but a little attention will enable you to observe, not without astonishment, that they are hollowed into a gutter throughout their whole length. Like other rushes, they are convex on one side: but they differ from them essentially in being concave on the other. By this character I discovered the spart, which is a rush of the mountains of Spain and is now employed at Paris to make cordage for draw wells.

The leaves of many plants, even in the plains, assume on their first appearance this form of a gutter or spoon, as those of the

violet and of most gramineous plants. In the spring you may perceive the young tufts of the latter raising themselves up towards heaven like claws to catch the drops, especially when it begins to rain: but most of the plants of the plains lose the gutter as they expand. It was given them only for the season necessary to their growth. It is permanent only in the plants of the mountains. It is scooped out as I have observed on the stalks of leaves, and in trees conducts the rain water from the leaf to the branch; the branch by the obliquity of its position conveys it to the trunk whence it descends to the root by a series of consequent dispositions. If you pour water gently over those leaves of a mountain shrub which are the most remote from its stem, you will observe it run off by the track which I have indicated and not a single drop will fall to the ground. I had the curiosity to measure in some mountain plants the inclination formed by their branches with their stems and I found in a dozen different species, as in the fern, the thuia, and others, an angle of about thirty degrees. It is exceedingly remarkable that this degree of incidence is the same as that formed in a horizontal plane by the course of many small rivers and rivulets, with the streams into which they discharge themselves as may be ascertained upon the maps. This degree of incidence seems to be the most favorable to the efflux of various fluids which direct themselves towards a single line. The same wisdom has regulated the level of branches in trees and the course of rivulets in plains. This inclination is subject to some varieties in several mountain trees. The cedar of Lebanon, for example, shoots the lower parts of its branches towards heaven, and bends the extremity downward toward the earth. They have the attitude of command which is suitable to the king of vegetables, that of an uplifted arm, the hand of which is inclined. By means of the first disposition the rain water is conveyed towards the trunk, and the second the snows, in the regions of which it delights glide from its foliage. Its cones have likewise two different positions, for it first bends them towards the ground, to shelter them at the season of flowering; but when they are fecundated it raises them up towards heaven. The truth of these observations may be confirmed by a young and beautiful cedar in the garden of plants at Paris, which though an exotic has preserved in our climate the attitude of a king, and the costume of Lebanon.

The bark of most mountain-trees is in like manner adapted to convey the rain water from the branches to the roots. That of the pine is in large perpendicular ridges; that of the elm is split and cleft longitudinally; that of the cypress is spungy like tow.

The plants of mountains and of dry situations have farther a character which is peculiar to them, in general, it is that of attracting the water which floats in the air in imperceptible vapors. The parietaria, or pellitory, which has derived its name "*a pariete*" because it grows on the sides of walls, has its leaves almost always humid. This attraction is common to most of the mountain-trees. All travellers agree in asserting that in the mountains of Ferro, one of the Canary Islands, there is a tree which every day furnishes that island with a prodigious quantity of water. The natives call it *garoe* and the Spaniards *santo* on account of its utility. They tell us that it is always surrounded with a cloud which distils abundantly down its leaves, and replenishes with water capacious reservoirs which are constructed at the foot of the tree, and afford a copious supply to the island. This effect is probably somewhat exaggerated, though reported by persons of different nations, but I give credit to the general fact. The real state of the case I take to be this, that the mountain attracts from afar the vapors of the atmosphere and the tree being situated in the focus of that attraction collects them around it.

Having frequently spoken in the course of this work of the attraction of the summits of different mountains the reader will not be displeased if I here present him with an idea of this portion of the hydraulic architecture of nature. Among a great number of curious examples which I could adduce and which I have collected among my materials on the subject of geography, I shall quote one extracted not from a systematic philosopher but from a simple and sprightly traveller of the last century, who relates things as he saw them, and without deducting from them any consequences whatever. It is a description of the peaks of the Isle of Bourbon situated in the Indian Ocean in the 21st degree of south latitude. It was drawn up from the papers of M. de Villers, who was then Governor of the island under the East

India Company. It is printed in the narrative of the voyage performed for the first time by French ships to Arabia Felix about the year 1709, and was published by M. de la Roque. 'Among those plains which are on the mountains of Bourbon,' says M. de Villers, the most remarkable, though no account has yet been given of it, is that which has been denominated the plain of the Caffres. In this plain there are a great number of aspen trees which are always green, the other trees have a moss more than a fathom in length, which covers their trunks and their large branches. They are dead, without foliage, and so impregnated with water, that it is almost impossible to make a fire with them. If with great difficulty you at length kindle some of the boughs, the fire is black without flame, yielding a reddish smoke, which spoils meat instead of dressing it; you can scarcely find in the whole plain a single spot where you can make a fire unless you choose some elevation near the peaks; for the soil of the plain is so humid that the water every where gushes out and you are continually in mud and wet up to the calf of the leg. * * * But from the thick fog which surrounds these peaks, from their continual haze, which wets as much as rain and which falls during the night, it is evident that they attract the vapors which the sun raises by day from the sea and which disappear by night. Hence is formed the sheet of water which inundates the plain of the Caffres, and from which issue most of the rivers and streams that water the island. A vegetable attraction is likewise perceptible in those ever-green aspens and trees constantly humid, with which it is impossible to kindle a fire. The island of Bourbon is nearly circular and rises out of the sea like the half of an orange. On the most elevated part of this hemisphere are situated the plain of Silaos and that of the Caffres, where nature has placed that labyrinth of peaks incessantly shrouded in fogs, planted like nine pins and lofty as towers.

If time and space permitted, I could demonstrate that there are a multitude of similar peaks on the chains of lofty mountains, of the Cordilleras, of Taurus and others, and in the centre of most islands, without the possibility of supposing, conformably to the received opinion, that they are the remains of a primitive earth which was raised to that height, for as we have before asked, what

could have become of the wreck of that earth the pretended evidences of which rise on every side upon the surface of the globe. I could make it evident that they are placed there in aggregations and situations adapted to the necessities of the earth, of which they are in some measure the reservoirs, some in the form of a labyrinth like those of the island of Bourbon, when they are on the summit of a hemisphere, whence they are destined to distribute the waters of heaven in every direction; others in the form of a comb, when they are placed on the lengthened crest of a chain of mountains, like the peaks of Taurus and of the Cordilleras; others grouped two or three together according to the configuration of the districts they water. They are of various forms and of different constructions, some are covered with earth, as those of the plain of the Caffres, and some of the Antilles islands, and which are at the same time so steep as to be inaccessible. These incrustations of earth prove that they have both fossil and hydraulic attractions.

There are others which are long needles of solid and naked rock; others are conical, or in the form of a table like the Table Mountain at the Cape of Good Hope, on which you may frequently see the clouds accumulate and spread out in the form of a table cloth. Others are not apparent but are entirely enveloped in the sides of mountains or in the bosoms of plains. All are distinguishable by the fogs which they attract about them and by the streams which flow in their vicinity. We may even rest assured that there exists not a single stream in the neighbourhood of which there is not some quarry of hydro-attractive and most commonly metallic stone. I ascribe the attraction of these peaks to the vitreous and metallic substances of which they are composed. I am persuaded that it would be possible to imitate this architecture of nature, and by means of the attraction of these stones to form fountains in the most parched situations. In general vitreous bodies and stones susceptible of polish are highly proper for this purpose; for when water is diffused in great quantity through the air, as at the time of a thaw, it is first attracted and adheres to the glasses and polished stone in our houses.

I have frequently observed on the summits of the mountains of the Isle of France effects similar to those of the peaks of the plain

of the Caffres in the Island of Bourbon. The clouds are incessantly collected around their peaks which are steep, and pointed like pyramids: some of these peaks are surmounted with a rock of a cubical form which crowns them like a capital, such is that which is there called Piterbooth after a Dutch admiral of that name: it is one of the highest in the island.

These peaks are formed of a solid rock, vitrifiable and mixed with copper; they are real electrical needles, both from their form and their substance. The clouds deviate perceptibly from their course to collect round them and sometimes accumulate in such great quantity, as to shroud them from the view. Thence they descend to the bottom of the vallies along the skirts of the forests, which likewise attract them, and there they dissolve into rain, frequently forming rainbows on the verdure of the trees. This vegetable attraction of the forests of this island so perfectly accords with the metallic attraction of the peaks of the mountains that a field situated in an open place in their vicinity, often suffers from the drought, while it is raining the whole year round in the woods at the distance of less than a musket-shot. By destroying part of the trees that crowned the eminences of that island, most of the streams which watered it were dried up: of these nothing now remains but the empty channels. To the same injudicious management, I ascribe the perceptible diminution of the rivers and streams in a great portion of Europe, as may be seen by their ancient beds, which are much too wide and deep for the volume of water they now contain. Nay, I am persuaded that to this cause must be ascribed the drought in the elevated provinces of Asia, among others in those of Persia, the mountains of which were, without doubt, imprudently stripped of trees by the first inhabitants. I am of opinion that if mountain trees were planted in France on the eminences and at the sources of our rivers, their ancient volume of water might be restored and many streams which have ceased to flow, would again appear in our fields. It is not among the reeds, nor in the depths of vallies, that the Naiads conceal their everlasting urns, according to the representations of painters, but on the summits of rocks, crowned with groves, and near to the heavens.*

Ibid, p. 242.

Although the complete proof of the subject now under discussion is of great importance to India and other tropical countries it must be allowed that further and more exact investigation will be required before the correctness of the foregoing statements be fully established. But as it is of consequence for the success of future inquirers to collect the existing information from the numerous works through which we find it scattered, I have purposely selected all that I remember to have met with in the course of my readings for insertion here.

Humboldt and St. Pierre must be regarded as valuable authorities, but there is also very concise information on this interesting subject to be found in a memoir by M. Boussingault, concerning "the effects which the clearing of land has in diminishing the quantity of water in the streams of the district."* Whether the labours of the agriculturist are effecting any modification in the climates of the countries subjected to their agency is an interesting question which is now very generally canvassed. It is moreover inquired, whether the immense clearing away of woods in some districts, together with the draining of morasses which exert so much sway over the distribution of heat during the various seasons of the year exert likewise an influence upon the streams and rivers which water the district, either by diminishing the quantity of water which falls, or by inducing a more rapid evaporation from the surface, when the wide spreading forests has been laid low, and its place been supplied by well cultivated fields.

A variety of observations would indicate that such a change has been, and is being, effected. In many localities it has been thought manifest, that, for a certain number of years, the streams which were employed in propelling water wheels have very sensibly diminished. In other places, many have been led to conclude that the rivers have become more shallow; and the increasing extent of their beds, covered with pebbles on either side appear to attest the disappearance of a portion of their waters. Finally many abundant springs are now almost dry. These observations have principally been made in valleys which are surrounded by mountains; and it has been thought apparent, that this diminution in the quantity of the waters, has been nearly coincident

* Jameson's Edin. Phil. Journal, p. 85, vol. xxiv., 1838.

with the epoch when the hatchet was employed, without mercy or judgment, against the woods which were widely distributed over the surface of the country.

These facts seem to indicate that in those regions where the process of clearing has been extensively carried forward, less rain falls than formerly. This in truth is the opinion which most generally prevails upon the point, and if admitted without further examination we must necessarily yield to the conclusion that the clearing away of the forests diminishes the annual quantity of the rain which falls upon the district. But on the other hand, even allowing that all the circumstances alluded to have been satisfactorily ascertained, still it has also been observed, that since the clearing of the mountains the different torrents and rivers which seem to have lost a portion of their waters occasionally manifest such sudden and extraordinary rises, that extensive devastations are the frequent consequence. It has likewise been observed, that after great falls of rain the springs which had almost entirely disappeared, suddenly rise with unusual impetuosity, only to subside with corresponding rapidity. The natural inference from these latter observations, as will be at once perceived, is that we are not too readily to adopt the common opinion and to admit that the cutting down of the woods diminishes the annual fall of rain, for it may not be at all impossible not only that the actual quantity of rain has not varied, but that the quantity of water passing off in the running streams may be really the same, in spite of the apparent drought at certain periods of the year both in the rivers and the springs; and possibly the only difference will turn out to be that the flowing of the same mass of water has, owing to the clearing, become much more irregular. In illustration, we may remark that if the small quantity of water which is found in the Rhone during a certain part of the year, was precisely compensated by a sufficient number of great floods, the necessary consequence would be that it still conveys to the Mediterranean the same volume of water which it did at the epoch anterior to the extensive clearings which have been effected near its principal sources, and when, probably, its mean depth was not, as it now is, subject to great variations. If these were actually the case the existence of the forests would be attended with this advantage that they would in some degree

regulate and equalize the flow of the water. But if on the other hand the whole annual quantity of the flowing water becomes less as the clearing away of the forests extends then the effect must be attributed either to the rains becoming less abundant or to its evaporation being promoted by the ground not being covered with trees and being thus deprived of shelter against the sun's rays and the wind. These two causes, which always produce a similar effect, must generally be combined. Before, however, endeavouring to estimate their influence, separately, it will be proper satisfactorily to ascertain if it be irrefragably established that the water courses of a country, where clearing has been extensively accomplished, are truly diminished, and thus assure ourselves that the mere appearance of the phenomenon be not taken for its reality. And, after all, this is the important point of the inquiry; for let it be once established, that the clearing of a country reduces the quantity of water in its running streams, the cause of this diminution is of secondary importance. We must now, therefore, inquire if we can find in nature a set of phenomena which will act as a criterion in resolving this question.

I regard lakes, whether met with in plains or in different stages of mountain chains, as highly qualified to throw light upon this discussion. These may be considered as natural gauges calculated to assist in valuing upon a great scale, the variations which may take place in the quantities of water which fertilize a country. If the volume of these waters undergo any variation, more or less, it is manifest that this variation, whether of excess or diminution, will be indicated by the mean level of a lake inasmuch as its mean level varies at different times of the year, according as the season is wet or dry. Thus the mean level of a lake will fall, if the annual quantity of running water in the streams of the district diminishes; on the contrary, it will rise, if these streams become more copious; and, finally, the level will remain stationary if the volume of water which runs into the lake experiences no change. In the following discussion, I have preferred the use of those observations only which relate to lakes which have no outlet; and the reason will be apparent as we wish to ascertain changes, which may not be very considerable. However I do not disregard such lakes as have an issue for their waters, for I am certain that the

study of such will also lead to very precise results. Before proceeding farther, I shall say a few words on the meaning I attach to the phrase, change of level.

It will not be disputed that one of the most interesting districts of the kingdom of Venezuela is the valley of Aragua situated at no great distance from the coast, possessing a warm climate, and a fertility of soil which can scarcely be surpassed. In it we observe every species of cultivation which distinguishes the tropics and upon the lesser hills which rise from the valley we observe with astonishment crops which remind us of European farming; corn grows admirably upon the heights which surround Vittoria. The valley is bounded on the north by the high land which forms the coast, on the south by the chain of mountains which separate it from Llanos, and both on the east and west a range of hills completely encloses it. By this very singular confirmation the rivers which take their rise within its enclosure have no issue, either towards the ocean or otherwise. Their waters therefore accumulate in the lowest part of the valley and form by their union the beautiful lake of Tacarigua, otherwise denominated Valencia. This sheet of water according to the testimony of M. de Humboldt exceeds in dimensions that of Neufchatel in Switzerland; it is elevated more than 1,300 feet above the level of the sea: its length is about thirty miles and its greatest breadth does not exceed seven or eight. At the time when M. de Humboldt visited this valley the inhabitants had long remarked the gradual drying up of the waters of the lake which had excited their attention for thirty years. But, in truth, it is only necessary to compare the descriptions supplied by the older historians with its present state, to recognise after allowing the largest deductions for exaggerations, that the waters have very considerably fallen. The facts themselves speak most distinctly.

Oviedo,* who towards the end of the fifteenth century, so often traversed the valley of Aragua, positively affirms that New Valencia was founded in 1555, at the distance of half a league from the lake of Tacarigua; and M. de Humboldt found, in the year 1800, that town was more than three miles (2700 toises) distant from its banks. The aspect of the district exhibits addi-

* His Historia de la provincea de Venezuela was published in 1723.

tional evidence of a great change. The rising grounds which are somewhat elevated above the plain maintain to the present day the name of islands, which at a former period, was most accurately assigned to them, seeing they were surrounded with water. The space which has been exposed by the retreat of the waters has been transferred into most fertile fields for the cultivation of cotton, sugar cane and the banana tree. Those buildings which were reared in the immediate vicinity of the water are seen to be more and more forsaken by it. New islands made their appearance in the year 1796. An important military post in the shape of a fortress which was built in 1740, in the island of Cabrera, is now situated on a peninsula. Lastly, in two islands of granite, those namely of Cura and of Cabo-Blanco, M. de Humboldt discovered among the bramble-bushes, several yards above the level of the water, deposits of fine sand containing many helecites. Facts which are so speaking as these, and withal so well ascertained, could scarcely fail of exciting the ingenuity of the learned on the spot, in the way of supplying explanations of the remarkable change, and they all agreed thus far, that some subterranean conduit had been opened up which allowed the waters to flow freely to the ocean. M. de Humboldt when on the spot paid all due regard to this supposition and after an accurate examination, of the localities, came very decidedly to the conclusion, that the cause of the diminution of the waters of the lake of Tacarigua was nothing more than the extensive clearing away of the woods over the whole valley, during the course of the former half century. 'In laying low the trees,' he observes, 'which covered the tops and flanks of the mountains mankind in all climates, are at one and the same time entailing two great calamities upon succeeding generations, they are producing a scarcity both of wood and water.'

Since the time of Oviedo, who like all the older chronologists, is perfectly silent concerning any subsidence of the water of the lake, the cultivation of indigo, sugar, cotton, and cocoa, had been carried to a great extent. In the year 1800 the valley of Aragua maintained a population as dense as that of any of the most populous portions of France. The smiling prosperity which existed in the numerous villages which teemed with its industrious popula-

tion, could not be witnessed without the greatest satisfaction. Such was the prosperous condition of this charming country when M. de Humboldt was sojourning in La Hacienda de Cura.

After a lapse of twenty-two years it was my lot afresh to visit the valley of Aragua. I fixed my residence in the small town of Maracay. I soon found that, for many years, the inhabitants had been remarking not only that the waters of the lake had ceased to subside, but on the other hand, they affirmed they were very decidedly rising. The lands which had been formerly occupied in the cultivation of cotton were now submerged. The islands of Las Nuevas Aparecidas, which had risen above water in the year 1796 had now become shallows which were dangerous for navigation. The tongue of land near to Cabrera, at the northern side of the valley, was now so narrow, that the smallest rise in the lake altogether inundated it: and a steady breeze from the north-west was sufficient to submerge the road which led from Maracay to Nueva Valencia.

The fears, which for so long a time had annoyed the inhabitants on its banks, were now altogether changed in their character: and they no longer dreaded the entire disappearance of the lake. They were now anxiously considering if these successive invasions of the rising waters were about to overwhelm their properties, and those who had explained the previous diminution by the existence of subterranean canals were convinced they were now choked up and that nothing would save them but re-opening these conduits afresh.

During the two and twenty years which had intervened, important political transactions had occurred. Venezuela now no longer belonged to Spain. The smiling valley of Aragua had been the arena of the most bloody contests, and war and death had desolated those happy scenes, and greatly reduced the population. On the first cry of independence, a number of slaves obtained their liberty by fighting under the standard of the new republic. Its wide spreading cultivation was neglected: the forest trees, so luxuriant within the tropics, had again in a great measure usurped dominion over that region which its inhabitants after a century of constant and painful labour, had reclaimed. During the growing prosperity of the valley of Aragua, the numerous streams which fed the lake had been arrested and employed in innumerable irrigations, and their beds

were found dry for more than six months of the year. At the last epoch to which I have alluded, the streams being no longer so diverted, flowed without interruption. Thus, then, during the progress and continuance of agricultural industry in the valley of Aragua, when the process of clearing was pushed farther and farther, and when cultivation in every shape was advancing, the level of the water gradually subsided. More lately, on the contrary, during a period of misfortune, and, we would fain hope, but temporary, when the clearing was no longer continued and the cultivated lands have fallen back into their wild state, the waters having ceased to fall, are now very speedily assuming a decided rising movement.

I shall now direct my remarks to another quarter, without however leaving America, in which we find a climate analogous to that of Europe, and where we traverse immense districts producing the most valuable grains. I shall direct attention to the higher lands of New Grenada, and to those elevated valleys from 6,000 to 9,000 feet above the level of the sea which enjoy, throughout the year, a temperature of from 58° to 62° Fahr. Lakes are frequent among the Cordilleras; I might easily dwell upon many of these, but shall bring under review only those which have been the subject of previous observations.

The village of Ubata is placed in the vicinity of two lakes. It is an important fact that sixty years ago, those two sheets of water formed one only. The older inhabitants have observed the waters gradually diminish, and their shores extend themselves year after year. Fields of corn of the greatest fertility at the present time cover districts which thirty years ago were completely covered with water. The falling of the mean level of this lake will the more readily be credited by the consideration that an occasional fall of three or four inches lays bear a great extent of surface. If we inquire in the neighbourhood of Ubata of any of the old men, who in their younger days were devoted to the chase, or if we examine the records of any of the different parishes, no doubt will remain that numerous forests have been felled. The clearing still goes on: and it is equally certain that the retreat of the water has not ceased, though it does not advance so rapidly as it was wont to do.

The lake of Fuquena in the same valley and to the east of Ubata deserves marked attention. By barometrical measurements, made

with the greatest care, I have found that its waters have precisely the same elevation as those of Ubata. It is now nearly two centuries since this lake was visited by Don Lucas Fernandes de Piedrahita, Bishop of Panama, to whom we are indebted for the History of the conquest of New Grenada. This author, whose accuracy I have frequently had occasion to admire and more especially as it respects distances, gives the length of the lake Fuquena at ten leagues, and its breadth at three. By a very happy coincidence Dr. Roulin a few years ago had occasion to construct a plan of this same lake, and he found the dimensions to be a league and a half in length and half a league in breadth.

It may be conceived by some, that the dimensions adopted by Piedrahita are exaggerated. But this is not my opinion, and supporting myself on the one side by my barometrical observations, and on the other by the silence which all the ancient historians have maintained respecting the lake of Ubata, a silence which is the more remarkable since they have described far less considerable bodies of water, I am inclined to believe that at the time that the Bishop of Panama visited this country there existed only a single lake, which extended without interruption from Ubata to Fuquena. In this view the calculation of Piedrahita is in no degree exaggerated. At any rate, the fact of the retreat of the waters is much more important than the estimate of the extent of surface which is left bare, a fact which is not questioned by any one. All the inhabitants of Fuquena know well that the village was built quite close to the lake, and now it is about three miles distant from it. In former times it was an easy matter to procure timber for building in the environs of Fuquena. The mountains, which rise on all sides of the valley, used to be quite covered to a certain height with the trees peculiar to these elevated regions. There was the Cordillera oak (encinos) in abundance; and also a great many laurels (myrica,) from which great quantities of wax were procured. Now the mountains are nearly entirely bare, which great change is chiefly owing to the working the salt springs of Taosa and Enemocon. To all these authentic facts, whose number might be increased, it may be replied that the disappearance of the water, however incontestible, might possibly have occurred had there been no clearing of the ground, and it might be contended that their failure is owing to a wholly different

though it may be an unknown cause, and so must be ranked amongst the many phenomena whose existence is ascertained, though any thing like satisfactory explications is beyond our power.

It is true I cannot adduce here, as I did in the former case of Lake Valencia, a returning increase of the water on the suspension of the cultivation, and the renewed appearance of the woods. I may, however, procure some support for the opinion I am propounding from the extreme slowness of the present desiccation of the valley of Fuquena, since there have been no more forests to cut down. The cultivators of the soil perceiving that there is no longer the same retiring of the waters as formerly and a corresponding appearance of land, have been thinking of some more direct method than the clearing by which they might attain the same end. It was with this object that some speculative individuals thought of a plan by which they might drain off the whole water by cutting a deep water course. But, instead of dwelling on such speculative points as these I shall here adduce a direct proof; and I believe it may be found in continued attention to the same class of phenomena we have been dwelling on; I proceed, therefore, to demonstrate, that those lakes which are so circumstanced that no clearing has ever taken place in their environs, are not subjected to any alteration of their level.

I begin with lake Tota, because it is not far distant from Fuquena; also because these two are in very similar circumstances in a geological point of view; and, finally, because it is the most curious lake that is to be met with throughout the whole of New Grenada.

The lake Tota is situated at a great height in the Cordillera of Sogamoso; its elevation is above 12,000 feet. At this height vegetation almost entirely disappears. In the year 1652 the road skirted, as it still does, the margin of the lake, and the Seiches, which occurred then as frequently as they do now, often made the journey sufficiently dangerous as it is confined between the lake and a wall of elevated rocks. The waters lave the said rocks, and their level has undergone no more change than the sterile and desert country which surrounds them.

It may here perhaps be objected that I ought not to have introduced as an element in this discussion, the description of a lake which is situated on the extreme limit of vegetable existence. In

the apprehension, then, that the instance I have selected, inasmuch as I regard it a striking one may be set aside for the reason it exists in a locality composed of rocks and almost denuded of vegetation, I shall supply the description of some others which are less elevated than is Tota, and whose waters have remained stationary for ages, although they are placed in the centre of a rich country, whilst at the same time its agricultural aspect has undergone no change. I have examined some such near the equator, in the province of Quito.

On leaving Ibarra to go to Quito, we traverse a delightful valley, in which we meet with the lake San-Pablo, to which the Indians continue its ancient name Chilcapan. I found it was elevated about 8,500 feet above the level of the ocean. The temperature corresponding to this height no longer admits the cultivation of wheat or of maize, but instead, we perceive numerous fields of barley, oats and potatoes. The lower parts of the country consist of the richest pasturage, and the hills are covered with sheep, which are reared for the sake of their wool which supplies the extensive cloth manufactures of the district. The numerous villages which border on the lake existed even previous to the conquest, the great mass of the population is still purely Indian, they still preserve their old customs and their idioms, and in short matters appear in much the state they were under the empire of the Incas. The only essential difference, perhaps, which it would be possible to point out is that the rearing of sheep has been substituted for that of the lama, although these latter animals are still by no means uncommon. On the public roads we frequently encounter droves of these lamas, under the directions of the Indians who attend them, and who by their means transport their merchandise from place to place. It is a fact admitted by every one that the steppe of San-Pablo from time immemorial has never been wooded. Even under the Incas it was pasture-land. Folds for sheep which were reared on the lake more than a century ago, are witnesses that its waters have in no degree receded. The route, too, which Huayna-capac followed when he left Quito to undertake the conquest of Otavalu, marks to the present day the limits of the water.

The Cordillera which separates the valley of San-Pablo from the coasts of the southern ocean is covered upon the eastern slope, with

thick forests which are almost impenetrable. I note this circumstance, because I have the strongest conviction that an extensive clearing of wood were it to take place even on a lower level than an alpine lake, and at a considerable distance from it, would still exert an influence over the mean level of its waters.

We may here also notice, without removing from the locality we have thus introduced to notice, the singular lake of Cuicocha, which occupies a trachytic basin in which two islands, which have been examined with much care by Colonel Hall, attest the stability and the uniformity of its level. The study likewise, of the lake Yaguarcocha, or the lake of blood, so designated since Huayna-capac dyed its waters with the blood of 30,000 Canra Indians, whom he there slaughtered, would lead to a similar result. Neither of these lakes have any outlet. Instead, however, of dwelling upon them, I shall in preference select Chilcapan lake, and especially because it has a natural issue towards the north, whence rises the river Blanco. I wish to show by this selection that, as I remarked at the commencement of this discussion, those observations which are made upon bodies of water with such outlets are not to be neglected. The effect we might expect to be produced by a stream issuing from a lake is, that the stream would deepen its furrow and consequently lower the waters. I have, however, observed that in spite of this circumstance the level of lake Chilcapan has not been sensibly lowered. In attentively examining the trachytic rock in the spot from which the river Blanco takes its rise I have not been able to recognise any indication of the water producing an eroding effect.

I shall conclude what I have to observe concerning the lakes of South America by a few remarks upon the one called Quilatoa, because it has been accurately examined at two epochs, which are sufficiently distant from each other, the one being the year 1740 on the other 1831.

In travelling to Latacunga, a town situated at no great distance from Cotopaxi, a great deal is often heard of the wonders of the lake of Quilatoa. From time to time this lake throws out flames, which envelop the shrubs on its edge; and it likewise produces frequent detonations which are heard at a great distance. These statements were more than sufficient to induce M. de la Condamine, who was at Latacunga in September, 1738, to undertake an excursion to

it. He found it was almost circular, with a diameter of about 400 yards. The water was about 120 feet below the level of its abrupt margin.

It happened that I, too, found myself in the neighbourhood of this same lake in the month of November, 1831. It cannot be compared to any thing so accurately as to a crater, the bottom of which is filled with water. I found that it was elevated 11,800 feet above the level of the sea, and hence was in the cold region. It is surrounded with immense pasture grounds, and, 1,500 feet below it, there are the sheep-folds of Piliputzin. To the east the Cordillera which descends towards the coast is covered with forests which are almost unknown. The information which the shepherds who live in its vicinity gave us had little in it of the marvellous so often associated with it. They had never witnessed any flames issue from its waters; nor had they ever heard any detonations. The result of my excursion to this lake was the observation, that all things, so far as level was concerned, were in the state they had been at the epoch of M. de la Condamine's visit.

The study of the lakes which are so numerous in Asia will probably lead to a result, in every respect conformable to that which has been deduced from the observation made in South America, viz., that the streams which water a country diminish in proportion as the clearing of it advances and its cultivation extends. The recent labours of M. de Humboldt who has supplied so much valuable information on this portion of the globe, seem to leave little doubt on this point. After having shown that the system of the Altai range extends by a succession of hills into the steppe of Kirghiz, and that, consequently, the Oural chain is not connected with that of the Altai, as has been generally supposed, this celebrated geographer demonstrates, that precisely at the place where we have been in the habit of placing the Alghinic mountains, a remarkable region of lakes commences which are continued into the plains which are traversed by the rivers Ichin, Omsk, and Ob. (See his Fragmens Asiatiques, t. i.) It might not be too much to say that these numerous lakes are the residue of the evaporation of a vast mass of water, which, in ancient times covered the whole country and which has been broken up into so many separate lakes by the configuration of the surface. In crossing the steppe of Baraba, that he might reach Barnaoul from Tobolsk

M. de Humboldt ascertained that the process of desiccation was every where greatly augmented by the effects of cultivation.

Europe also possesses its lakes, and these we have still to examine in relation to the subject before us. My own progress through Switzerland was much too rapid to allow me sufficiently to attend to the light these waters throw on this interesting point. My regret, however, is the less severe as fortunately a most illustrious observer has left some valuable documents which supply new proofs of the influence of cultivation upon the diminution of the quantity of water in the district.

Saussure, in his first researches concerning the temperature of the Swiss lakes, examined those which are placed at the foot of the lowest line of the Jura range. The lake of Neufchatel is eight leagues long whilst its greatest breadth does not exceed two leagues. In visiting this lake Saussure was impressed with the conviction that its limits at an early period must have been much more extensive; for, says he, the great level meadows and the swamps which terminate at the south-west extremity, have undoubtedly been covered with its waters. The lake of Bienne is three leagues long and one broad. It is separated from that of Neufchatel by a succession of plains which to all appearance were formerly under water. The lake Morat is also separated from Neufchatel by a level morass which no one doubts was formerly submerged. Formerly then, says Saussure, the three great lakes of Neufchatel, Bienne, and Morat were united in one great basin. In Switzerland, then, as in America and Asia, the ancient lakes which we may distinguish as the primitive ones, those which occupied the lower portions of the valleys, when the country was wild and uncultivated, have subsequently been separated into a certain number of independent ones by the drying processes to which it has been subjected.

I shall terminate my task by availing myself in this discussion, of the observations of Saussure upon the lake of Geneva. This interesting object was, as it were, the spot from whence the celebrated philosopher commenced his immense labours. No one ever studied it more deeply than he did.

Saussure admits that, at an epoch much anterior to the times of history the mountains which surround the lake were buried under water; some vast catastrophe occasioned a great disruption and

speedily the current of waters occupied no greater space than the bottom of the valley ; in short, the lake of Geneva was then formed. But turning from this to the monuments which have been constructed by man it is impossible to doubt that during the course of twelve or thirteen centuries, the waters of the Lake of Geneva have considerably retired. This is evident from the flat shores it has left near its margin, and, even in the town itself, the Quartier de Rive and the low streets have been built upon such sites. This lowering of the surface, continues Saussure, is not the result only of the wearing down of the channel whence its waters issue, it has likewise been produced by diminution of the quantity of the waters which flow into it. The general result which may be safely drawn from the observations of Saussure is that during the period of twelve or thirteen centuries, the running streams have gradually diminished throughout the districts in the neighbourhood of the lake of Geneva. And there is no one, I believe, will dispute that during that long period, there has been a vast clearing away of wood and a rapidly increasing advance in the cultivation of this beautiful country. Upon the whole, by the examination of the levels of lakes, we have arrived at this conclusion, that in those countries which have been extensively cleared, it appears very probable that there has been a diminution of the running streams which flow through the district, whilst, on the other hand, where no great change has been effected in this way, the streams have been subjected to no variation.

Great forests, therefore, in the point of view we are now regarding them appear to have the effect, first, of preserving the volume of water destined for the use of machines and of canals, and then to be an obstacle to the rain water collecting and running off with too much rapidity, being at the same time an obstacle to evaporation. That a surface covered with trees will not be so favourable to evaporation as a well wooded one is what every one will admit, without discussion. But that the difference of these two conditions may be adequately appreciated, it is necessary that the traveller should successively pass through a country which has been cleared and one which has not some time after the rainy season is over. It will then be seen that the portion of his journey in the forest is still covered with mud while those in the open country are completely dried. It is especially in South America that the obstacles to evaporation in a

region shaded with thick forests are conspicuous. In these situations the humidity is perpetual, even long after the rainy season is past. The paths which are formed through them are during the whole year nothing better than sloughs, and the only method of drying these forest roads is to make them as broad as 200 or 300 feet, which in fact is a method of clearing them.

When it is once admitted that the running streams are diminished as the result of clearing, it may then be important to examine whether this diminution arises from the quantity of rain being lessened, or from the greater evaporation, or finally if it be owing to irrigation.

I have already admitted at the commencement of this paper that it was nearly impossible to assign any exact proportions to these different co-operating causes. I shall, nevertheless, in conclusion, endeavour to appreciate their respective influence in a general way. And the discussion will subserve one important object if I prove that there may be a diminution of the running streams from the clearing alone without the simultaneous action of the other causes.

First, with regard to irrigation we may remark that it is necessary to distinguish between the case where extensive cultivation takes the place of a forest and that in which a sterile district which was never wooded becomes cultivated under the efforts of human industry. In the former case it is probable that the irrigation will contribute little or nothing in effecting any alteration in the mass of running water; for it must be generally admitted that the quantity of water consumed by the vegetation of any given surface of forest, must equal if it does not exceed, that which would be absorbed by an equal surface devoted to culture after it has been cleared. From this it follows, that the influence exerted by this cultivated district corresponds to the condition of lands which have been cleared acting solely by favouring the evaporation of the rain water. In the latter case again that is to say where a great extent of uncultivated land shall have been reclaimed, there will be an evident consumption of water by the vegetation which has been there promoted: and the introduction of agricultural industry will under these circumstances tend to diminish the water-courses which traverse the country. It is very probable that we are to attribute to this circumstance the gradual drying up of the lakes which to a certain extent gauge the

running streams of the north of Asia. It is almost useless to add, that under circumstances of this nature, the effect produced by the simple evaporation of the rain water is not augmented ; on the contrary it ought to be rather less, for on a soil covered with plants water will not so readily evaporate as on one destitute of vegetation.

Again in the considerations I have supplied concerning the lakes of Venezuela, of New Grenada, and of Switzerland, the disappearance of a part of the flowing streams, which are tributary to these lakes, might be attributed simply to a more limited fall of rain ; whilst on the other hand, with quite as much reason it might be maintained it was the consequence solely of the more rapid evaporation of the rain water. Beyond doubt there are circumstances under the influence of which the diminution of the streams is the result simply of a more active evaporation. I meant to have produced a good number of examples bearing on this point. But in a discussion of this sort it is not so much numerous as well authenticated facts, that it is important to supply. Influenced by this consideration I shall limit myself to the production of two facts ; the one derived from M. Desbassyn of Richemond, who observed it in the isle of Ascension ; and the other drawn from my own notes being one of the observations I made during a sojourn of many years at the mines of Marmato.

In the island of Ascension, a beautiful spring has been noticed situated at the foot of a mountain which was originally wooded, by degrees the spring was less copious, at length failed ; during this process the forests were cut down and the mountain was cleared. The disappearance of the spring was attributed to the clearing. The mountain was again planted, and after a few years the spring re-appeared, became gradually more productive and finally was as copious as ever.

The metalliferous mountain of Marmato is situated in the province of Popayan in the midst of immense forests. The stream of water upon which the stampers are placed is formed by the union of many small brooks which take their rise on the plateau of San Jorge. The whole environs of the establishment are thickly studded with wood. In the year 1826, when I for the first time visited these mines, Marmato consisted of some miserable huts possessed by a few Negro slaves. In 1830 the epoch at which I quitted this locality, Marmato exhibited the most exhilarating appearance. There were now seen

great workshops, a foundry for gold, and powerful machines for the division and amalgamation of this precious metal. There was now a free population of nearly 3,000 inhabitants settled on the mountain side. All this implies that the wood had been extensively cut down for the manufacture of the machines, the construction of the buildings and the preparing of charcoal. That it might be the more easily carried on all this was done upon the plateau of San Jorge itself. The clearing had been going on for scarcely two years, when it was noticed that the quantity of water which was required for the machines had conspicuously diminished. The volume of water is in fact measured by the work which the machines perform; and trials by gaging, at different times, have likewise proved the diminution of the water. But this is at Marmato an all important subject, for a diminution of the fluid moving power is always followed by a diminution in the production of gold.

In these two cases of Marmato and Ascension it is not at all probable that an extent of clearing so local and limited could have such an effect upon the meteorological condition of the atmosphere, as in any degree to vary the annual amount of the rain which falls throughout the country. But the question need not be left in this uncertainty. At Marmato as soon as the diminution of the supply of water was ascertained a rain-guage was established, and it was found, by the observation of the second year that a greater quantity of rain had fallen than during the first, although the clearing had been continued and there was no appreciable increase of the quantity of water at the wheels. Two years of hydrometrical observations are sufficient even in the tropics to exhibit the variation in the annual quantity of rain, and the observations at Marmato establish that the mass of running water has diminished at the very time that the quantity of rain had increased.

It is then probable that local clearings of no great extent may diminish the copiousness of springs and rivers, and even cause them to disappear, and under circumstances where these effects can in no degree be attributed to a diminution of the fall of rain.

Finally, we have still to examine if the extensive clearing of forests, extending over considerable districts has any effect in making the rain less copious? In reply we remark that it is only hydrometrical observations that can lead to the solution of this question. And unfor-

tunately the observations of this sort which might be at our command, do not reach back far enough and, so far as Europe is concerned, they were not commenced till the whole clearing process was well nigh over. The United States of America, however, where the forests are disappearing with astonishing rapidity, may perhaps supply the required data at no distant period.

In studying the phenomena of rain under the tropics I have at length formed, in connection with this question of clearing, a very decided opinion, which I have freely communicated to many. I regard it certain, then, that a very extensive clearing diminishes the annual quantity of rain which falls upon a country.

It has long ago been remarked, that, in equinoctial regions the epoch of the rainy season returns every year with astonishing regularity. This is most true, whilst at the same time this meteorological fact ought not to be announced in terms too general. There is the greatest possible regularity in the alternation of wet and dry seasons in those countries whose territory is very much varied. Thus a country which at once exhibits forests and rivers, mountains and great plains, lakes and extensive table lands, will at the same time exhibit periodic or changing seasons with a regularity which is quite remarkable. This, however, is no longer true if the territory be more uniform, and if it become in any way peculiar. The epoch of the return of the rainy season will be much less regular if the face of the country be exposed and arid; also if cultivation to a great extent has partially taken the place of forests; and finally if the rivers are numerous, the cultivation be but limited, then the irregularity of the seasons will still manifest itself, but with quite a different character. Rain will then predominate, and in some years it will become, so to speak, continual.

The continent of America presents to us, in immense extent, two regions which are placed under the same conditions as to temperature, and in which we successively meet those circumstances which are the most favourable to the formation of rain and those which are of directly opposite character. In leaving Panama, and travelling towards the south we pass the Bay of Cupica the provinces of San Buena Vantura, of Choco, and of Esmeraldas. In this country, covered with thick forests, and furrowed by a multitude of rivers the rains are almost unceasing. In the interior of Choco, no day passes without rain. On

the other side of Tumbez towards Payta, an entirely different set of objects present themselves. The forests disappear, the soil is sandy, and of vegetation there is scarcely a vestige. Here rain, so to speak, is unknown; when I was at Payta, according to the testimony of the inhabitants, it had not rained for seventeen years. This want of rain is common in all the countries which border on the desert of Sechura, and extends as far as Lima. In these countries rain is as seldom seen as are trees.

Thus, in Choco, whose soil is covered with forests, it rains continually; on the coast of Peru, the soil of which is sandy, devoid of trees, and destitute of verdure, it never rains; and this, as I have already said, under a climate precisely the same as to temperature, whose exposure and distance from the mountains is very nearly the same. Peru is not at a greater distance from the Andes of Assuay than are the humid plains of Choco from the western Cordillera.*

In the case of Marmato the evidence furnished by the rain guage proved beyond a doubt that the diminution of the running water was not owing to a diminished fall of rain, as it was found by the observations of the second year that a greater quantity of rain had fallen than during the first; nor do I imagine the diminution was solely owing to the lands being deprived of the protection from the sun's rays which the leaves and branches afford, but the lands being cleared the fallen leaves and roots of the trees no longer existed to retard the flow of the water which fell: while 3,000 inhabitants of an active flourishing settlement engaged in the cultivation of the articles indispensable to the existence and comfort of man would soon cause on the table land of San Jorge the great change in the quantity of spring water which is the result of high cultivation, or agricultural improvement of a country. While the face of a country is rough the rain water remains long among its inequalities, slowly sinking into the earth to feed the springs or slowly running away from the surface, as from bogs and marshes, towards the rivers. The rivers hence have a comparatively gradual and regular supply even when rain has not fallen for a long time, but in a well drained and well cultivated country the rain by a thousand channels finds its way to the brooks and rivers, almost immediately, producing often dangerous floods or inundations of the neighbouring low grounds.

* Jameson's Edinburgh Phil. Journal, p. 85, vol. xxiv. 1838.

In addition to the moisture which trees bring to the earth in the form of rain they furnish a valuable supply by condensing the fogs which occur. In heavy fogs, in elevated situations especially, trees are perfect alembics, and no one, who has not attended to such matters, can imagine how much water one tree will distil in a night's time by condensing the vapour which trickles down the twigs and boughs so as to make the ground below quite in a float.

Trees in leaf have such a vast proportion more of surface than those that are naked, that in theory their condensations should greatly exceed those that are stripped of their leaves; but as the former imbibe also a great quantity of moisture it is difficult to say which drip most; but this I know, that deciduous trees that are entwined with much ivy seem to distil the greatest quantity. Ivy leaves are smooth, and thick, and cold, and therefore condense very fast; and besides evergreens imbibe very little. These facts may furnish the intelligent with hints concerning what sorts of trees they should plant round small ponds that they would wish to be perennial; and show them how advantageous some trees are in preference to others.

Trees perspire profusely, condense largely, and check evaporation so much that the woods are always moist, no wonder, therefore, that they contribute much to pools and streams. In Newton Lane in October on a misty day, an oak in leaf dropped so fast that the cart-way stood in puddles and the ruts ran with water though the ground in general was dusty. That trees are great promoters of lakes and rivers, appears from a well known fact in North America; for since the woods and forests have been grubbed and cleared, all bodies of water are much diminished: so that some streams, that were very considerable a century ago, will not now drive a common mill. Besides, most woodlands, forests, and chases, with us abound with pools and morasses, no doubt for the reason given above.

Trees require a great quantity of water to supply their organs. This is given off in perspiration by their leaves. In the experiments of Hales, of the quantity of water taken up by plants, it was found that a pear tree which weighed seventy-one pounds, absorbed fifteen pounds of water in six hours and that branches of an inch diameter, and from five to six feet high, sucked up from fifteen to thirty ounces in twelve hours. When these were stript of their leaves, they only sucked up one ounce in twelve hours.

The house in which we resided in Fife was built on a greenstone rock on the south brow of the high ground overlooking the beautiful river Leven, about two hundred feet above its level, and five hundred feet distant from it. We there remarked that, even in closets in the garrets, shoes and all kinds of leather, soon become mouldy, which could be produced only by the moisture generated by the trees, which in thick groves closely surrounded the house.*

Trees in full foliage have long been noted as great attractors of humidity and a young wych elm in full leaf affords a good example of this supposed power; but in the winter of the year when trees are perfectly denuded this faculty of creating moisture about them is equally obvious though not so profusely. A strongly marked instance of this was witnessed by me, when ascending a hill in the month of March. The weather had previously been very fine and dry, and the road in a dusty state; but a fog coming on an ash tree hanging over the road was dripping with water so copiously, that the road beneath was in a puddle, when the other parts continued dry and manifested no appearance of humidity. That leaves imbibe moisture by one set of vessels and discharge them by another is well known, but these imbibings are never discharged in falling drops: the real mystery was the fog in its progress was impeded by the boughs of the trees, and gradually collected on the exposed side of them, until it became drops of water, whereas the surrounding country had only a mist flying over it. Thus in fact the tree was no attractor, but a condenser; the gate of a field will in the same manner run down with water on the one side, and be dry on the other, as will a stick or a post, from the same cause. It is upon this principle that currents of air will be found under trees in summer, when little is perceived in open places and the under leaves and sprays will be curled and scorched at times, when the parts above are uninjured. The air in its passage being stopped and condensed against the foliage of the tree, it accordingly descends along its surface or front and escapes at the bottom where there are no branches or leaves to interrupt its progress. In winter there is little to impede the breeze in its course, and it passes through; consequently at this season the air under a tree is scarcely more sensibly felt than in the adjoining field.†

* White's Natural History of Selborne, p. 195.

† Journal of a Naturalist, p. 61.

Similar phenomena are constantly observed when the air is full of moisture, after the rainy seasons of India. One of the most marked instances which have fallen under my own observation, however, was one morning in 1838 to the westward of Secunderabad. The first hour's ride lay over a bare plain, the sand on which betrayed no appearance of moisture, but on entering a plantation enveloped in a fog my clothes were soon saturated by the fog, which existed there, being condensed by the leaves overhead. In the islands lying in the tract of the south-east trade winds, their mountain summits covered with wood are formed by the leaves and branches into an unceasing condensing apparatus, while the closeness of the trees and the dense foliage prevent the ground they shade ever drying. This was finely shown to me in December, 1834, when in the Isle of France. At sunrise along with some companions, I left the plains on which were growing the orange, the pine-apple, and the palm trees of the tropics, and advancing up the mountain we first passed over ground cleared of wood where the sheep of the farmers were grazing, and then entering upon a small tract which led directly up the mountain we soon became involved in the gloom caused by the shade of the gigantic black wood trees which grow there. We passed by several immense masses of rock which having been detached by some accident from a higher situation, had come sweeping down the mountain's side, leaving in their tracts uprooted and overthrown trees.

Shortly after we entered this forest it rained for a short time but soon cleared up; but when we had almost reached the summit a fog so dense came on that our party wandered from the road, this fog was so fast condensed by the leaves of the trees that the drops fell from them much more rapidly than the rain had fallen, and before the slaves, who were our guides, could extricate us from the forest, we were completely drenched. I had gone up with the intention of collecting specimens and had only obtained one (the hedgehog of tropical climates and supposed peculiar to Madagascar) when this condensation of vapour commenced, and while being thus drenched from the fog on the summit of the hill the sun was shining on the plains and the reports from the fowling pieces of the sportsmen there were heard every minute.

This remarkable condensation of the moisture in the air of the mountains of the Mauritius may possibly have been observed by all who have ascended them, as Mr. H. Hayter describes having wit-

nessed a similar phenomenon when lately climbing to the tops of the Peter Botte mountain there. At dawn of day, he says, we snatched a hasty breakfast and were fairly on the move by six o'clock. Our route lay up a steep ravine at the lower part of which grows a dense forest of ebony and " bois de natte" through which we made our way and soon got completely wet through from the dripping of the dew from the branches of the trees and long grass.*

There is one more means by which the vegetable world collects the moisture of the atmosphere, viz. by forming dew. Although the advantage a climate derives from this is not so apparent, yet the supply obtained is by no means scanty or devoid of utility, for it assists in the nourishment of the plant and enables it to supply the wants of man with its fruits and to scent the air with the fragrance of its flowers. When it is mentioned that the quantity of dew deposited during the year in Britain is reckoned at five inches, (half the quantity of the rain, which fell in 1838 at Bellary,) the agreeable freshness such a quantity of moisture will cause when again becoming vapour will readily be comprehended. The quantity of moisture taken up by the atmosphere during the day very much influences the quantity of dew which falls at night. Dew is first deposited on the bodies, which radiate heat most powerfully as grass, twigs, and leaves of trees; some trees however, are even famous for the quantity of water they collect from dews which hang about them, and there is not, perhaps, among all the numerous examples that occur of the provident economy of nature in the vegetable world, a more remarkable instance than that displayed in a plant commonly met with in Ceylon and other islands of the east, and which has obtained the appropriate name of the pitcher plant.

Being the inhabitant of tropical climates, and found on the most dry and stony situations, nature has furnished it with the means of obtaining an ample supply of moisture without which it would have withered and perished. To the footstalk of each leaf near the base is attached a kind of bag, shaped like a pitcher, of the same consistence and color as the leaf in the early stage of its growth, but changing with age to a reddish purple. It is girt round with an oblique band or hoop and covered with a lid neatly fitted and moveable on a

* Recent ascent of the Peter Botte Mountain, by Mr. Hayter, Illustrated London News, p. 142, 2d September, 1848.

kind of hinge or strong fibre which passing over the handle connects the vessel with the leaf. By the shrinking or contracting of this fibre the lid is drawn open whenever the weather is showery or dews fall, which would appear to be just the contrary of what usually happens in nature, though the contraction, probably, is occasioned by the hot and dry fibre: and the expansion of the fibre does not take place till the moisture has fallen and saturated the pitcher. When this is the case, the cover falls down and it closes so firmly as to prevent any evaporation taking place. The water being gradually absorbed through the handle into the footstalk of the leaf, gives vigor to the leaf itself and sustenance to the plant. As soon as the pitchers are exhausted, the lids again open to admit whatever moisture may fall, and when the plant has produced its seed and the dry season fairly sets in it withers with all the covers of the pitchers standing open.

The manner in which Providence has contrived a supply for the thirst of man in dry situations is equally worthy of admiration. On some parched districts of Africa nature has planted a great tree called by the negroes Poa, the trunk of which of prodigious bulk is naturally hollowed out like a cistern. In the rainy season it is replenished with water, which it keeps cool during the most intense heat by means of the tufted foliage which crowns its summits. Finally, she has placed vegetable fountains on the arid rocks of the Antilles; you commonly find on them a liane called the water liane, so full of sap that if you cut a single branch as much water is immediately discharged as a man can drink at a draught: it is perfectly pure and limpid. In the lagoons of the Bay of Campeachy travellers find relief in a different manner: these lagoons, on a level with the sea, are almost entirely inundated in the rainy season, and are so parched in the dry season that hunters who have accidentally lost their way in the forests by which they are covered, have actually perished of thirst. The celebrated navigator Dampier relates that he several times escaped that calamity by means of a very extraordinary species of vegetation, which had been pointed out to him on a kind of pine very common in those parts. It resembles a parcel of leaves placed one over the other in stages and on account of its form and the tree upon which it grows he calls it the pine-apple. This apple is full of water, so that on piercing the lower part of it with a knife a good pint of very clear and wholesome water immediately

flows from it. Father du Tertre relates that he often found the same kind of refreshment in the horn shaped leaves of a species of balisier, which grows on the sandy shores of Guadaloupe. I have heard many of our sportsmen remark that nothing is more proper for quenching thirst than the leaves of the misletoe which grows on our trees.

The thick green leaves of plantain trees readily condense the moisture of the atmosphere, and there is at all times within their different layers a quantity of pure clear water which may be collected by making an aperture in their stems. A tree of a similar character exists in the Mauritius, and the first time I became aware of this I received an agreeable surprise when the gardener at Pamplemoos plunged his knife deep into its stem and allowed the stream of pure water to spring in a jet from the wound.

Such are in part the precautions employed by Providence, to compensate in favor of man the inconveniences of every climate by opposing to the qualities of the elements contrary qualities in vegetables.*

The facts detailed seem to establish,

1st. That the extensive clearing of a country diminishes the quantity of running water which flows over its surface.

2d. That it is impossible for us to determine, at present, whether this diminution is owing to a smaller annual fall of rain or to an increased evaporation of the surface water, or to these two causes combined.

3d. That it is however shown by the authors above quoted that rain oftener falls, and that more dew is deposited in well wooded countries than when the country is naked; and, drawing our conclusions from the meteorological facts collected in equinoctial regions, we may presume that the extensive clearing of a country diminishes the actual quantity of rain which falls upon it.

4th. That mountains, particularly when covered with their native forests, by an electric action on the atmosphere, cause clouds to form around them; collect and condense the vapours of the air, and equalise the fall of rain.

5th. That the forest trees which grow on mountain summits have a structure peculiarly fitting them to receive the waters of the clouds.

6th. That lands destitute of the shelter of trees allow of more rapid evaporation.

* St. Pierre's Studies of Nature, vol. ii. p. 322, ed. 1846.

7th. That independent of the preservation of surface water forests husband and regulate its flow.

8th. The above authors also show that in all forest tracts the temperature of the air is more equable throughout the year: that in tropical regions the atmosphere around trees is cooler and contains more moisture than the air on the open glade; that the atmosphere of a tropical country without trees, has an arid dryness in it totally dissimilar to the cool softness of a well wooded one; that lands covered with trees are cooler and moister than those which are exposed: that in hot climates the destruction of forest trees, by inducing aridity, destroys vegetation; and that forests and trees afford the shelter from violent winds which is absolutely essential to the health of the vegetable creation.

9th. That springs draw their supplies from sources in their immediate vicinity, and the presence of trees near these sources, seems to prevent the dissipation of the supply of water.

10th. That in clearings which are purely local springs may disappear without there being any ground to conclude that the annual quantity of rain has diminished.

11th. That the tenacious clayey under-soil found in forests is peculiarly adapted for preserving the surface and subsoil waters.

12th. That there is a difference in the condensing power of trees, but, by means of the vegetable creation, a valuable supply of moisture is collected from fogs, and from the atmosphere in the form of dew.

If the facts detailed warrant these deductions it may be confidently asserted, that Southern India would be greatly enriched and its climate ameliorated by the introduction of arboriculture.

It is only the government or the civil servants of the state who could accomplish any thing on a great scale, but their efforts may be seconded by every individual resident in it, and the man who makes a few trees grow where none grew before will be a benefactor to this country.

It is highly improbable that this cultivation would ever be carried to an excess likely to injure the health of the neighbouring inhabitants. The danger to Europeans at least, are purely imaginary and equally so in my opinion to the native population, although their spare diet and spare forms, their food and mode of life greatly expose

them to the influence of vitiated air. But even with every excess we may with full confidence assert that the increased mortality which many most gratuitously assume as the inevitable consequence of much vegetation, would never amount to five hnndred thousand, the number of the native population that are said to have died in 1839, in India, of famine alone.* A famine sweeping whole cities nay whole districts from the earth must far exceed, in the amount of misery and number of deaths it occasions, the hardships which would be entailed on a family by one of its members being carried off from a more sickly climate, even supposing that the planting of trees would ever become excessive or cause a climate to become worse, which I do not believe.

Many famines have occurred in this country and one or two of them may have been caused by wars, and other causes unconnected with climate, but most of them have been owing to droughts, and our efforts to prevent their recurrence must be made to procure an ample supply of water; for rich as the soil is in many parts of India, the soil acts a very secondary part. In a tropical country water is all in all: for let the soil be ever so stony or sandy a good supply of water will make various grains spring from it in abundance. But to obtain our utmost supply of water from the atmosphere we must plant trees: to prevent the rain as soon as it falls from rushing to the rivers and thence to the ocean, in fact to retard its flow and thus be enabled for a longer period to employ it for agricultural purposes, we must plant trees, and we must plant trees in order to have a few springs of water trickling from the mountain sides.

Were the hills in India covered with trees neither the torrents, which rush from them during the rainy season, nor the dry cracked and burned up appearance that they present during the hot season would longer be seen. If we can imagine the mountains in the Mauritius near the Petre Botte or the Petre Botte itself instead of being covered with tall trees to be perfectly bare of wood, in the first place none of the clouds which so frequently hang on their summits would ever be condensed, and the rain if it fell would rush down the rocky sides of the mountains in torrents, their beds becoming dry the moment the rain ceased; but with their well clad sides much water is

* *Agra Ukhbar* for January, 1840.

derived from the clouds which would otherwise fly off without contributing to the earth's demands, and both this supply and that which falls on them as rain runs slowly among the roots of the trees and under shrubbery to the plains below, or sinking into the crevices of the rock it springs out at a lower level, affording to the inhabitants a continual supply of pure water.

Considering the great numbers famines* have destroyed it cannot seem an unnecessary anxiety again to urge that trees be extensively planted to obtain a more abundant and more regular supply of rain for the country, to endeavour to prevent their recurrence. And while effecting this object we would likewise be obtaining wood for economic purposes, and when it is mentioned, that in many parts of the peninsula of India, the natives use masses of granite or hornblende rock as wheels for their carts, it is superfluous to make further comment on the scarcity of this useful article.

It is not my object here to allude to the mode of cultivation, nor to the species of trees which should be cultivated, but I may just remark that in cold climates where there is abundance of water, shelter from the inclement winds seems the great want to be provided for; while, in this country, the chief provision required, is water. But should the recommendation now made ever be acted upon, there seems no occasion for Government to incur the unnecessary expense that would be the result of planting good productive land with trees of a description difficult to rear or requiring to be attended to and watered for years; for besides the fact that it is the forest trees on mountains, which are most useful, there are some kinds of trees which will take root and grow any where, and if such be selected and their seeds sown at the proper seasons many of the unproductive lands in India might be covered with trees, and thus become subservient to man.

EDWARD BALFOUR, Assistant Surgeon,
Madras Army.

* Within the first five years from our first acquisition of the technical sovereignty of the Bengal Provinces in 1765, a famine prevailed which swept off in two years time one-third part of the entire population—probably an exaggeration, but which is not denied by any party—destroyed as many of the human race as the whole inhabitants of the present kingdom of Holland.

Extract from the Minutes of Consultation.

Para. 1. The Right Honorable the Governor in Council has perused with much pleasure and satisfaction, the valuable and very interesting Report furnished by Assistant Surgeon Balfour on the effect of trees on the climate and productiveness of a country, and deeming it of importance that the local Revenue Officers should be in possession of information so intimately connected with the welfare of the districts under their respective charges, he resolves to direct that copies of the same be printed at the *Fort St. George Gazette Press* for general distribution and for transmission to the Government of India, and the Governments of Bengal, Bombay and Agra, and the Honorable the Court of Directors.

2. In Extract Minutes of Consultation, dated 8th October, 1847, No. 1116, the Government called for information on the same subject through the Board of Revenue, and it is the intention of the Governor in Council similarly to have printed and circulated for the use of the Revenue Officers all reports which may be deemed by the Board as useful and inducing suggestions for practical purposes.

3. It will be for the Board of Revenue when they shall have received all the information forthcoming on this subject to consider the measures it will be necessary to take to prevent the too great clearance of forests where they exist, and to promote their growth where they do not, or where they have been thinned. The propriety of restricting leases for large tracts of forest land for cultivating purposes should also be had in view, and every opportunity taken in connection with the usage and rules for planting topes and trees in the several districts, of forming continuous and extensive plantations of wild trees of large growth in suitable positions. It is believed that when the local Officers interest themselves in the welfare of a district and feel how much of it is dependant on the growth of forests, neither difficulty nor the expense of raising up forest tracts will be great. It is the practice at present in some districts to make an annual disbursement for planting palmyras for Revenue purposes, an extension of the principle, and a judicious selection of the sites and description of trees seem alone necessary to ensure success in the department to which the Home and the Indian Governments have now turned their attention.

4. Various other points may occur to the Board, or suggest themselves on a perusal of the reports which may be furnished to them, and the Government expect that the Board will take the same interest as they themselves feel, and propose for practical operation whatever they may consider conducive to the well being of the country.

5. The Governor in Council resolves to furnish to Assistant Surgeon Balfour a copy of the foregoing Proceedings, and to convey to him at the same time the thanks of Government for his interesting communication.

REVENUE DEPARTMENT.

No. 488.

Extract from the Minutes of Consultation, under date the 18th May, 1849.

Read the following letter.

No. 9.

From Major General W. CULLEN, *Resident at Travancore and Cochin.*

To J. F. THOMAS, *Esq., Chief Secretary to Government, Fort St. George.*

SIR,—I have the honor to acknowledge receipt of a letter from the Secretary to Government No. 1118 of the 8th October, 1847, with its enclosures, copy of a letter from the Government of India, and of a despatch from the Honorable the Court of Directors, requiring information "respecting the effect of trees on the climate and productiveness of a country or district, and the result of extensive clearances of timber."

From my own knowledge of the features and general appearance of these two provinces, Travancore and Cochin, I was not of opinion that any such considerable, and at the same time permanent clearances of forest lands had taken place within the last half century, as to cause any sensible effect upon the climate or productiveness of the country.

I have observed in various places partial clearings, but these appear to have generally been followed by the abandonment of equal tracts of previously cleared land, for the clearances have not been the consequence of a steadily increasing population, and therefore permanent in their nature, but chiefly from the mere nomad propensities of a scanty hill population, aware of the superior fertility of all such newly reclaimed land. The heaviness of the rains and the

general fertility of the soil, rapidly promoting the regrowth of forests on the tracts previously cleared. At the same time I have no doubt that the process of clearing is slowly advancing under these sirkars, and that it may in due time have a certain effect on the climate and apparent productiveness.

I have been able to procure but little satisfactory information on these subjects from individuals settled in the country, but I have forwarded herewith copy of a letter from the Dewan of Cochin, as also copy of a private note from the Reverend Mr. Mault, of the London Mission Society, who has been settled for the last 30 years nearly at Nagercoil in the south of Travancore, and who has had much opportunity of observation in his visits to his different schools and chapels in the interior.

It is facts, as the Reverend Mr. Mault observes, however, and not opinions, that are really valuable, but after all, how few are the facts that are procurable ; we can obtain little else any where than the result of casual observation and experience :—the remarks even of the celebrated Humboldt appear to be supported by but few, if any, actual meteorological data.

On the effect of cutting down forests he observes, that " they affect the copiousness of springs, not as was long believed by a peculiar attraction for the vapours diffused through the air, but because by sheltering the soil from the direct action of the sun, they diminish the evaporation of the water produced by rain."

" When forests are destroyed, as they are every where in America by the European planters, with an imprudent precipitation, the springs are entirely dried up or become less abundant."—Personal Narrative, vol. 4, p. 143-4—and

Again " with the destruction of the trees, and the increase of the cultivation of sugar, indigo, and cotton, the springs and all the natural supplies of the lake of Valencia have diminished from year to year." Vol. 4, p. 144.

No meteorological observations, however, are given in support of these conclusions, at least not in the Personal Narrative.

Monsieur A. Moreau de Jonnes, a Staff Officer in the Army of Belgium, obtained about the year 1828 a prize for an essay on these subjects, from the Philosophic Society of Brussels. He maintained:

1st. That " the clearing of woods makes the temperature of countries warmer."

2d. "That more rain falls on the sea coast than in inland districts, and that, when chains of mountains run parallel to the sea shore, the sides next the sea receive more rain than their opposite sides."

3d. "That woodlands in flat countries do not perceptibly increase the quantity of rain, but that woods on mountains have a perceptible influence in producing that effect."

Monsieur Moreau de Jonnes' work is stated to have originated in representations at the commencement of the French Revolution, of the injurious effects on the climate, &c. of France by the rapid cutting down of forests.

In France in 1750 the woods are stated to have occupied $\frac{1}{4}$ of the surface of the country; in 1788, $\frac{1}{7}$, and in 1814 only about $\frac{1}{13}$. In England, according to M. Moreau de Jonnes, the woods occupy only about $\frac{1}{23}$ of the surface.

There is also an interesting paper on the subject of climate, as affected by the clearances of forests, in Silliman's American Journal of Science and Art, by Dr. Forry of the United States.

"Dense Forests," he observes, "and all growing vegetables, doubtless tend considerably to diminish the temperature of summer, by affording evaporation from the surface of their leaves, and preventing the calorific ray from reaching the ground."

"Snow lies longer in forests than on plains, because in the former locality, it is less exposed to the action of the sun."

"At Hudson's Bay the ground in open places thaws to the depth of 4 feet, and in the woods to the depth of only 2 feet."

"Moreover, it has been determined by thermometrical experiment, that the temperature of the forest at the depth of 12 inches below the surface of the earth, is, compared with the adjacent open field, at least 10° lower during the summer months, while no difference is observable during the season of winter."

Lyell in his principles of geology observes, that "in the United States of N. America it is unquestionable, that the rapid clearing of the country has rendered the winter less severe, and the summer less hot; in other words, the extreme temperature of January and July have been observed, from year to year, to approach nearer to each other: whether in this case, as in France, the mean temperature has been raised seems by no means yet decided, but there is no doubt that the climate has become, as Buffon would have said, 'less excessive.'"

Dr. Forry remarks on the above passage that " it is unsustained by any well observed facts."

Dr. Webster, another American writer on the climate of N. America, arrives from a most extensive investigation of historical facts at the conclusion, " that the winters have been from the first settlement of America variable; now mild, now severe, just as they are in the present age." A leading object with him is to show the error of Dr. Williams, who, having maintained that the mean temperature of Italy " has increased 17°, wished to establish some analogous change in our climate since its occupation by Europeans, and Doctor Webster proves most conclusively, that, if Doctor Williams is unfortunate in his facts, he is still more so in his reasonings and deductions."

Dr. Webster concludes with the following passage as the result of clearing the forests.—" From a careful comparison of these facts he says, it appears that the weather in modern winters is more inconstant, than when the earth was covered with wood at the first settlement of Europeans in the country; that the warm weather of autumn extends farther into the winter months, and the cold weather of winter and spring encroaches upon the summer," &c.

Dr. Forry concludes his interesting paper with the following remarks: " that climates are susceptible of melioration by the extensive changes produced on the surface of the earth, by the labors of man, has been pointed out already; but these effects are extremely subordinate, compared with the modifications induced by the striking features of physical geography, the ocean, lakes, mountains, the opposite coasts of continents, &c."

Again: " The fallacy of the opinion which ascribes the mild climate of Europe to the influence of agricultural improvement becomes at once apparent, when it is considered, that the region of Oregon lying west of the rocky mountains, which continues in a state of primitive nature, has a climate even milder than that of highly cultivated Europe in similar latitudes; and again, China situated like the United States on the eastern coast of a continent, though subjected to cultivation for several thousand years, possesses a climate as rigorous, and some assert even more so, than that of the United States on similar parallels."

It is singular, however, that in the foregoing elaborate paper, no

estimate is attempted to be formed of the actual area cleared of forests within the last hundred years.

My own attention has of late years been much given to the subject of the fall of rain, as connected with the vicinity to high ranges of mountains:—I had noticed the accounts of the great annual fall of rain on the Mahabaleshwar hills, and at Merkara in Coorgh; and several years ago, with a view to similar observations, I established a rain guage on the summit of the high range of ghat mountains 22 miles east of Trevandrum, and where I found the fall of rain to be from 4 to 6 times the quantity on the sea coast. The obstruction to the passage of the vapour from these mountain chains, and its consequent condensation, the monsoon winds being nearly at right angles to the line of ghats, seemed to me to offer so decided and satisfactory an explanation of the phenomena, that I at once adopted it. These observations on Uttree Mullay and other tables of the fall of rain, which I have for several years past been collecting, although without reference to, or in illustration of any particular theory, may be of some interest in the present inquiries, as to the effect of forests in promoting the fall of rain.

I have established rain guages all along the sea coast from Cape Comorin to the latitude of Ponany, and I have also by the assistance of friends, been enabled to get several sets or lines of registers running directly inland; and perpendicular to the line of coast, for a distance of about 60 miles; thus exhibiting, not only the effect of distance from the sea, but also that of contiguity to the great chain of ghats separating Malabar from the provinces of the Carnatic.

The first of these inland lines is from Quilon to Shenkotah and Palamcottah, with rain guages at

	Distance.	Altitude above Sea.	Rain.
	Miles.	Feet.	Inches.
INLAND LINES.			
Quilon,	Sea Coast	25	65
Kept by W. Huxham, Esq. — Puttnapoorum	25	150	99
Kept by W. Huxham, Esq. — Shalakurray,	30	160	106
Kept by W. Huxham, Esq. — Koraventavalum,	36	350	113
Kept by W. Huxham, Esq. — Caldoorty,	41	750	128
LINE OF GHATS.			
Shenkotah	52	600	44
Palamcottah	70	150	24

It will be observed from the map, that Puttnapoorum the 1st station from Quilon, at 25 miles from the sea, is just where the high road enters the mass of high mountain ridges and spurs running out from the great chain of ghats.

From hence to the pass through the ghats, an interval of about 20 miles, is a dense mass of chains and groups of high mountain ridges from two to four and five thousand feet in altitude, running parallel to each other in a north-westerly direction, and covered with primeval forests. The gradual increase in the fall of rain up to Caldoorty at the very base of the ghats is very remarkable, as well as its sudden decrease on the east of the ghats at Shencottah, an interval of only 12 miles, causing a diminution from 128 to 46 inches.

There are no forests of consequence at Puttnapooram, nor for several miles farther to the eastward, and the fall of rain therefore should have diminished rather than increased as we proceeded inland; but, as I have already noticed, the groups and chains of mountains commence at that place, and they become more numerous and higher as we approach the main line of ghats.

The increase therefore, in the fall of rain at Puttnapooram, and from thence to Caldoorty, I should be disposed to ascribe almost exclusively, to the obstruction offered to the passage of the vapour over these high chains of mountains, and to its consequent condensation, and in no way to any effect of the forests.

Very remarkable examples of this effect of continuous chains of high land, in arresting and condensing the passage of the vapour have been recently afforded in the tables of the fall of rain on the Mahabaleshwar hills, at Mercara in Coorgh, and on the table land called Uttree Mullay, in the chain of ghats east of Trevandrum, and published in the proceedings of the British Association for the advancement of science—all of these places being from four to nearly five thousand feet above the sea.

Uttree Mullay is a continuous mass of high land, running for several miles nearly parallel to the coast, in the latitude of Trevandrum, and upwards of 4,500 feet above the sea. While the fall of rain at Trevandrum is only from 50 to 60 inches,—on Uttree Mullay it is not less than, from 240 to 280 inches.

The slopes of the mountains are clothed with forests of tall trees, but on the summit, although with much wood, the trees are comparatively dwarf and stunted.

Dalton with reference to the effect of mountains in augmenting the fall of rain observes, that "the inferior, warm, and vapoury strata of air, striking against the mountains, are made to ascend into the colder regions, by which means the vapour is precipitated; the situation of places however, may be too high to experience an extreme in this respect, thus the rain in Switzerland and amongst the Alps is not probably greater than the north of England." So Ootacamund on the Neilgherries, where the rain is under 50 inches, would seem to be "too high;" it is above the ordinary plane of precipitation, or lower stratum of cloud vapour; besides which, it is 15 miles east of the line of ghats, and 770 miles from the sea coast; whereas, Uttree Mullay is only 22 miles from the sea and immediately on the western crest of the ghats.

The county of Cumberland in England also affords some interesting illustrations of the effect of mountain masses, in arresting and condensing the vapour:—In a paper by Mr. Miller, of Whitehaven, on the fall of rain in the lake districts of that county, he shows, that the fall in 1844-1845 at Gatesgarth, close into the mountains was 88$\frac{1}{2}$ inches, and at Seathwaite in Borrowdale, 56 inches in 7 months, (equal to upwards of 100 inches in the whole year)—while in the more open parts of the county at Keswick and Whitehaven, the fall was only 44 and 38 inches respectively.

23. The second line of rain observations is from between Alleppy and Cochin on the sea coast, nearly east to Thodawully, at the base of, and to the Perreyaar river, &c. on the central or cardamom table lands of Travancore, with rain guages as follows:

	Distance. Miles.	Altitude. Feet.	Rain. Inches.
Alleppy and Cochin, (mean)	Sea Coast	12	100
Thodawully,.....	30	120	142
Perreyaar river,..... On the Table Land, ...	50	2500	84
Top of Cummum Pass, ...	60	3500	38

From Cochin to Thodawully is in the low country, but on leaving Thodawully, which like Pathanapooram is just at the commencement of the spurs and ridges running out from the main chain of ghats,—you ascend a very beautiful and extended table land, the first station on which is at the Perreyaar river in the very centre of the upper country; the 2d station Cummum is on the eastern crest of the table land, overlooking the low country of Dindigul.

The fall of rain at Thodawully at 30 miles from the sea is even greater than that at Caldoorty on the Quilon line at 40, but the fall of rain appears to increase as we go north, on the sea coast, as well as inland, and the actual difference here, between the coast and the inland stations, is less than on the Quilon line, as might be expected from the spurs and ridges from the main chain of ghats being of less depth and less altitude.

At Shalakurray, 30 miles from the sea, the fall is nearly double that at Quilon,—whereas at Thodawully, also 30 miles from the sea, the fall is barely half more than at Cochin or Alleppy.

A third series of observations is about 35 miles north of Cochin from the sea coast, near Chowgat by Trichoor to the town of Chittoor in the Cochin district of the same name, and in the very midst of the great opening in the ghats at Palghatcherry.

I have no observations at Chowgat, but have assumed that it is the same as at Cochin thus:

	Distance. Miles.	Altitude. Feet.	Rain. Inches.
Chowghat,.....	Sea Coast	12	88
Trichoor,.....	12	50	101
Chittoor,.....	52	300	60

I was not prepared at first to account for the greater fall of rain at Trichoor, 12 miles inland, for the country immediately about it is flat and open, but there are numerous and continuous high chains of hills crossing the whole country, to the eastward, within 5 or 6 miles; and it may therefore be considered as another and most interesting proof of their effect, in augmenting the fall of rain.

On the two former lines the fall of rain increased as the mountain tracts were approached and entered, but on this last line the very reverse takes place, the fall of rain at Chittoor 52 miles from the sea being only 60 inches, or but little more than one half of the fall on the coast; but on this line, although crossed by a belt of forest, there are no mountain chains to intercept and lead to condensation of the vapour, and which is of course therefore rapidly absorbed by the dry and heated air of the province of Coimbatore on the east of the ghats.

There cannot perhaps be a more beautiful illustration of the effect of mountain chains, in arresting and condensing the vapour, than the generally luxuriant forests which clothe the eastern as well

as the western ghats, but which cease almost immediately on quitting those chains. The forests on the east coast as might be expected, are less lofty and luxuriant than those in Malabar, not only from the fall of rain on the east coast being only half that of Malabar, but also because they are in general double the distance from the sea, the chief source of all vapour.

There can of course be little question as to the effect forests must have during a great part of the year, in preventing the dissipation of the superficial moisture, but I should doubt if that circumstance can have much influence on the supply of water from springs. The effect of the sun's rays on the earth, even when fully exposed to them, is sensible to but a very inconsiderable depth from the surface, and not at all so far as the subsidence of the water forming springs. The copiousness of springs must be influenced so much by a variety of other causes, as to render the effect of forests hardly appreciable. The vicinity to elevated table lands and mountains and hills, the nature of the rocks, and inclination of the strata, the general slope of the country, the absorbent qualities of the soil, &c. &c. must all have the most important influence. At Trevandrum, even on eminences, the wells at a depth of 40 feet from the surface rise occasionally several feet with a fall of rain of only the same number of inches, and within two or three days after heavy falls.

In the forests of this coast and above the ghats in the western parts of Mysore, Wynaad, and Coorgh, the trees are I believe every where nearly destitute of leaves, during the early part of the year, the driest and the hottest season, so that, even in forest tracts, the earth is at that period exposed to nearly the full force of the sun's rays.

The long grass and low jungle is also generally burnt down in these months, and the general heat and dryness in passing through such tracts are frequently intolerable. The almost entire absence of moisture and springs in forest tracts in the dry season is well known.

The district of Ernaad in Malabar, formerly so celebrated for its teak forests, and still I believe with much forest of other kinds, is I believe for the most part a plain and nearly level, but in the hot season is like the other tracts, I have noticed, equally destitute of vegetation and moisture, and I speak of these facts from having, although many years ago, passed over all the tracts in question.

The forests in this quarter therefore, whatever beneficial effects they may have during the rains or cooler portions of the year, would seem to exercise but little influence on the general climate, or in the preservation of moisture, at the very season when it is most required.

If forests maintain a lower temperature during the day, they equally prevent direct radiation, and induce a higher temperature during the night, while they must always be pervious to the strong and dry winds that prevail during one season of the year.

The Ceded Districts, meaning thereby chiefly the Collectorate of Bellary, although in the very midst of the Peninsula, and its capital, at least, 200 miles from either coast, in a country also nearly destitute of forest tracts and mountain chains, and 1,600 feet above the sea, is hardly a drier climate, or with less rain than the province of Tinnevelly, which is hardly above ¼ the above distance from either coast, frontiered by the chain of ghats, and with more forest or jungle tracts, and not above 200 feet above the sea.

The average annual fall of rain at Bellary is about 20 inches, but has occasionally been as little as 8 or 10 inches.

The fall of rain at Bellary was in	
1822.....24 inches.	At Palamcottah the
1823..... 7½ „	average is.....26 inches.
1824.....19½ „	But in 1848 there
1828.....24½ „	was only about.....15 „
1838..... 9½ „	

The fall of rain at Coimbatore was in

1845.....23 inches.	1846 .....13½ inches.
1847.....34 „	1848.....19½ „

These two districts, to which may be added Coimbatore, appear to be, as far as regards the fall of rain, the driest perhaps under the Madras Presidency, or perhaps in any part of our Indian Empire, with exception of Scinde.

But small as is the fall of rain in the district of Bellary, the springs of water are I believe abundant, the slope of the country and the nature of the strata being favorable to their development. I recollect in the country about Raidroog, 40 miles South of Bellary, large holes were every where sunk from 25 to 30 feet deep, through the disintegrated and decomposed gneiss, where copious springs abounded, and carrying off channels from thence, the water was

brought (by the natural slope of the ground) to the surface within a few hundred yards, and fine streams obtained for irrigation even in the month of April. These springs were neither the result of forest tracts, nor of the condensation of vapours by elevated mountain chains, but had their origin in the mass of elevated land to the west of Raidroog which is some hundred feet higher, and some remarks on which, and the Soondoor mountains, I submitted to Government in my report of 21st October, 1846.

Dry and hot as the climate of Bellary has been considered, and disagreeable as it certainly is during the hot months of May and June, I do not observe such differences in the actual temperature, &c. as might perhaps have been supposed to exist.

From some observations made in the year 1824, I find the mean temperature to be in the month of:

	5 A. M.	3 P. M.	
April	76°	91½	hot season.
May	79°	93½	
While, at Madras, in June	81½	91½	hot season.
July	81½	91½	

The comparative low temperature with light westerly air at day-break at Bellary is, if I recollect correctly, a remarkable feature in its climate. It seemed to me to be caused by the strong sea breezes on the western coast at that season, and which reaching Darwar by the afternoon or evening, at the rate of 12 or 15 miles per hour, arrives at Bellary in the middle of the night or towards morning, where the rapid absorption of the vapour necessarily produces a fall of temperature.

I have traced the strong sea breezes of the Malabar coast nearly all across the Peninsula on different lines. At Seringapatam we used to look anxiously for its approach in the months of April and May, and where it generally arrived nearly as at Darwar about 8 or 9 P. M., causing an instant rise of several degrees on Saussure's hair hygrometer, and most agreeable to the feelings.

For instance in 1828:

	Temp.	Saussure's Hair Hygror.
17th March at 5½ P. M.	87°	7°
9	84°	51°
14th May 5¼	88°	18°
8¼	85°	54°

The arrival of the sea breezes from the Malabar coast may also be noticed occasionally at Bangalore, in the months of April and May, sometimes early in the night, but more generally towards morning.

Between Sedasheaghur and Mangalore the line of ghats is every where, I believe, of but moderate altitude, not probably any where above 2,000 feet, and without high chains of mountains, so that the sea breeze can pass over them at that season without any material obstruction, and to the influence of these moist breezes from the sea may possibly in part be ascribed the success of the cotton cultivation experiments to the west of Darwar.

These are points to which I have not observed that very much attention has been given, or at least few observations recorded. The temperature of the different seasons has been attended to, but not so much so I think the fall of rain, or the degree of humidity in the atmosphere. The climate of the southern or cotton districts of America, New Orleans and Florida, is noticed by Dr. Forry as remarkable for its equable temperature as well as its extreme humidity.

He says " This remarkable equality in the distribution of temperature among the seasons in Florida, compared with the other regions of the United States, constitutes its chief climatic peculiarity."

In regard to humidity, he adds :

" That the air is much more humid than in our more northern regions is sufficiently cognizable to the senses." The deposition of dew even in the winter is generally very great. To guard against the oxidation of metals " as for instance surgical instruments, is a matter of extreme difficulty. During the summer, books become covered with mould, and keys rust in one's pocket."

How different must be the climate of our Indian Cotton districts of Bellary, Coimbatore, and Tinnevelly.

The tables of rain in the foregoing papers are original, and the first I believe of their kind. They were set on foot, as I have already noticed, without the view of explaining any particular theory of climate. The extraordinary quantity of rain that fell on the high table land of the ghats near Trevandrum first drew my attention to the subject, and the theory of the condensation of the vapour caused by the mountain chains seemed to offer so perfect an explanation that I sought for no other. A farther investigation of the subject sug-

gested by the inquiries of the Honorable the Court of Directors, has not led me to attribute any very great influence to forests in the production of rain, but my remarks of course apply chiefly to the peculiar physical features of these two provinces of Travancore and Cochin, so remarkable from their great mountain barriers running parallel to the sea coast for 200 miles, intercepting the course of the monsoon, and no where above 40 miles distant, and the intermediate space towards the sea covered with innumerable high ridges and spurs from the main chain.

It will be observed from the letter of the Dewan of Cochin, that like myself he does not appear to have perfectly understood the meaning of the Court's queries as to how far the clearance of forests affected the moisture or productiveness of the soil. On inquiry I find that he merely contrasts cultivation under the shade of forest trees, with that on the same lands when cleared of forest. In the one case the growth of grain is rank and does not ripen, while in the other from the freshness and richness of the natural manure from decayed vegetable matter, it is vigorous and productive and in the same way that while the lands covered by forests are almost invariably wet and moist, after being cleared the moisture disappears.

These were results however, which few would question. My doubts were whether the Court adverted to the effect of extensive clearances on the lands previously under cultivation, to the general effect on the climate, on the fall of rain and on the original sub-stratum or sources of spring water, or whether it was meant to apply to the productiveness of the forest lands when recently cleared, compared with the productiveness of the same lands several years afterwards.

Of course from land cleared of dense forests the superficial moisture will be more speedily dissipated by evaporation, and when the same lands are brought under cultivation there must also be a corresponding local expenditure of water from the springs or rivers or other sources especially in warm climates.

This will lead probably to a partial and local (apparent) diminution of such sources of supply, but it can rarely I think materially affect a climate. The water that is evaporated, or absorbed by cultivation, will in the one case be ultimately restored to the land

by the periodical rains, and in the other will add by percolation to the supplies of lands on a lower level.

The wetness of the land said to be so remarkable in the extensive tracts of forests that cover a large portion of the interior of South America, I should be disposed to ascribe less to the obstruction offered by the abundance of decayed vegetable matter on the surface than to the want of slope in the soil to carry off the rain water.

The plains of the river Amazon at 3,000 miles from the Atlantic are stated by Humboldt to be not more than 1,200 feet above the sea, giving a slope of only $4\frac{3}{4}$ inches per mile in a direct line, and not probably half of that by the course of the rivers. In the south of India the slope will seldom I believe be found less than 4 or 5 feet per mile on a direct line.

I have the honor to be, &c.

RESIDENT'S OFFICE,
Cochin, 31*st March*, 1849.

W. CULLEN, M. G.,
Resident.

P. S.—About the same time that I received the order of the Government to prepare this report, I also received a similar communication from the Board of Revenue requesting my opinion on the question; and as I observe that the Government have entrusted to that Board the duty of drawing up a general report on the subject, I hope I shall merely have been anticipating the wishes of the Right Honorable the Governor in Council, in transmitting direct to that Board a copy of this communication.

Original Tables of the fall of Rain, by General CULLEN.

QUILON TO PALAMCOTTAH.

	Miles 25	30	36	41	52	70
	Quilon.	Puttana-pooram.	Shala-curray.	Koraven-tavalum.	Caldoorty.	Shencot-tah.	Palam-cottah.
		150 Feet.	100 Feet.	350 Feet.	750 Feet.	600 Feet.	150 Feet.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1844	60	102	113	115	123	24	$11\frac{1}{4}$
1845	62	83	88	112	114	43	$25\frac{1}{4}$
1846	$74\frac{1}{2}$	98	103	97	136	$41\frac{1}{4}$	18
1847	$83\frac{1}{2}$	132	123	134	158	70	47
1848	46	79	103	106	106	$32\frac{1}{2}$	15
Mean..	65	99	106	113	128	$42\frac{1}{4}$	24

Alleppy to Cummum.					Chowghat to Chittoor.			
Miles.... 31		50		60	Miles....14		12	52
	Alleppy.	Thodawully.	Perreyar river.	Cummum.	Cochin or Chowghat.	Shalacoody.	Trichoor	Chittoor
		120 Feet.	2500 Feet.	3500 Feet.		50 Feet.	50 Feet.	300 Feet.
1844	119	143	—	—	102	—	110	58
1845	98	133	81	42	93	91	115	61
1846	113	150	113	42	106	90	114	52
1847	131	172	—	—	125	87	112	77
1848	85	115	57	30	76	30	52	53
Mean..	109	142	84	38	88	72	101	60

	Cape Comorin.	22 Uttree Mullay.	Trevandrum.
	63 Feet.	4600 Feet.	120 Feet.
1844	19¼	—	47
1845	18	290	62
1846	56	236	69
1847	46	262	79
1848	24	209	41
Mean..	35	249	59¼

W. CULLEN, *Resident.*

Copy of a Letter from the Dewan *of* Cochin.

No. $\frac{439}{1847}$.

To Major General W. Cullen, *British Resident of Travancore and Cochin.*

Sir,—I have the honor to acknowledge the receipt of your letter No. 1484, under date the 21st October last, with its enclosure (copy of a letter from the Secretary to the Government of India to the Secretary to Government Fort St. George, and also one from the Hon'ble the Court of Directors), and in reply to state, that it does not appear that there have been any such extensive clearances of forest in the Cochin country as to affect or influence the fall of rain.

Clearances, however, have taken place in different directions to a limited extent from one to four miles, and have been in every instance followed by decreased moisture and an increased productiveness in the soil.

I have the honor, &c.

(Signed) Shungra Warrier,

Dewan.

Huzzoor Cutcherry, Ernacolum, in Cochin, 8th December, 1847.

The letter from the Reverend Mr. Mault of Nagercoil, I have mislaid, but its purport was, that he was not of opinion, that any clearances of forest had taken place during his residence of near 30 years in the south of Travancore, to an extent that could in any way affect the climate—but he joined in the very general opinion, that forests promoted and preserved moisture.

W. CULLEN, *Resident.*

Extract from Minutes of Consultation.

Para. 1. The question at issue in the correspondence that has passed upon the subject is, whether "the clearing of extensive forest lands is not likely to cause a diminution in the quantity of rain and thereby a failure in the sources from which the springs are supplied." The report, which is otherwise important and interesting, does not appear to supply any specific data on these points, and although chiefly applicable to a peculiar region where rain is certain, it yet presents some anomalies as to quantities in the same parallels inland which do not appear to be accounted for. The Right Honorable the Governor in Council finds much valuable matter which may be turned to account by those taking an interest in the subject, and he resolves in pursuance of the intentions declared in Extract Minutes of Consultation, dated 8th September, 1848, No. 981, to have Major General Cullen's report printed and distributed in the same manner as the paper by Dr. Balfour, to induce those who have already written to lay before Government any further suggestions which may occur to them, as well as to enable those who have not so written, to avail themselves of the information it affords and mature their views.

2. As a copy of the Report is before the Board of Revenue, they will be requested to notice it with the other communications they may receive on the same subject.

3. The Governor in Council resolves to furnish to Major General Cullen a copy of the foregoing proceedings, and to convey to him at the same time the thanks of Government for his valuable and interesting communication.

A true extract.

H. C. MONTGOMERY, *Secretary to Govt.*

Report of Surgeon C. I. SMITH, *of the Mysore Commission, on the effect of Trees on the Climate and Productiveness of a Country.*

To the Secretary to the Commissioner for the Government of the Territories of His Highness the Rajah of Mysore.

SIR,—I have the honor to forward for submission to the Commissioner, the following observations on the influence of trees in modifying and altering climate, and more especially in regard to the effect of their clearance in diminishing or otherwise the annual supply of rain.

In Mysore there has not been any clearance of wood to an extent sufficient to bear upon the question, and in the absence of meteorological observations in the jungly districts, we must avail ourselves of the only other mode of gaining information, viz., popular opinion. The superintendent of Coorg, in answer to a Circular from the Commissioner's Office, writes as follows: "They (the Coorgs) are fully impressed with the belief that to clear them (the jungles) extensively, would tend greatly to diminish the quantity of rain and of water in the rivers, and thereby destroy their paddy cultivation, the principal produce of Coorg, and also render the inhabitants less healthy,—thus it will be observed, that the general belief mentioned in the 3d para. of the Honorable Court's despatch, extends itself to the Coorgs."

The only part of Coorg that has been recently cleared is a small district on the west bank of the Cauvery, around Kooshalnuggur, for the purpose of establishing a cantonment for the corps of Sappers and Miners,—the influence of this small clearance on the falls of rain has not been remarked.

The opinion of the superintendent of Nuggur is, that the clearance of trees diminishes the quantity of rain,—speaking of the clearances and the destruction caused by coomri cultivation, he says "it causes the most rapid destruction of the forests, which, it is a well ascertained fact, lessens the quantity of rain and moisture, and must thus in the course of no very long time seriously affect the cultivation and prosperity of the country."

The superintendent of Chittledroog writes as follows: "There is not much scope for forming an opinion founded on experience and observation within the limits of this division as respects the influence of trees on rain; there are no forests or extensive jungles, or ranges

of high and wooded hills; there is, however, a difference in the features of Chittledroog or the northern division, and the Toomcoor or southern division of this district; there are very few large trees, and but limited garden cultivation on the Chittledroog side, while trees are numerous, and garden cultivation extensive on the Toomcoor side;—in the former locality, there are occasionally wet seasons, and heavy falls of rain, but the quantity of rain generally falls far short of the supply in the latter locality; in the absence of the data afforded by the clearing of a forest or the extensive cutting down of trees, or the restoration of such, it would be difficult to decide whether extensive garden cultivation and planting of trees has originated in, or produced, the more abundant supply of water; but I am inclined to adopt the latter conclusion."

The above extracts show that the opinions of the superintendents, and of the natives of this country, are in favor of the notion that the presence of trees in a country tends to increase the quantity of rain. One passage in the superintendent of Chittledroog's letter is worth notice, viz., that heavy falls of rain are frequent in the Chittledroog or northern part of his district. In that part of the country are barren ranges of granite hills, which, it is not unlikely, attract electric clouds accompanied by torrents of rain. The heaviest falls of rain in Mysore are in October and November during the north-east monsoon, and these showers are always accompanied by thunder and lightning.

On the 4th of October, 1846, an extraordinary storm of this sort broke over the hills to the north of Toomcoor, in the Chittledroog district, 10 inches of rain fell in 4 hours, and burst the bunds of nearly all the tanks over a range of 80 miles. The presence of trees appears in some way to modify these sudden bursts of rain and to equalize the falls, as similar thunder storms are common in the immediate neighbourhood of Seringapatam, where rocks are abundant and verdure scanty. The talooks in which most rain falls, apart from the hill country, are exactly those in which are the largest amount of jungle, Shemogah, Chennagherry, Terrikerry, and again down to the south in Heggadadavencottah and the talooks skirting the Coorg jungles and hill country, and then inland following the line of hills which runs from the Neilgherries and separates Mysore from Coimbatoor. In the Bangalore division, or eastern district of Mysore, the line of jungles from Severndroog to the Cauvery, including

the talooks of Closepett, Kankanhully, and Harohully, receive the most rain,—except these last named talooks in the Bangalore division, the others are all either bordering on lines of hills clothed with jungle or have extensive tracts of jungle which may fairly be supposed to influence the quantity of rain.

I have appended to this report a return showing the quantity of rain measured at particular spots in the four districts of Mysore for the last 12 years, a reference to which will show how little can be deduced from such varying results. The whole of the observations were taken in the open country. Rain gauges kept at a distance of 2 or 3 miles vary remarkably in the quantities measured, observations of this sort may, however, become valuable if taken for a series of years in different parts of India with similar instruments, as by comparing the quantities of rain measured in jungly and open districts, an approach may be made to some certain results.

In the Mulnaad and Coorg the quantity of rain that falls is very great, and to what can we attribute this, but to the influence of the ghauts and hilly country inland covered with dense jungles, which attract and retain the largest portion of the south-west monsoon. Bellary, Seringapatam, and Ootacamund are nearly in the same parallel of longitude, but at different distances from the line of ghauts, and to this circumstance we may attribute the difference in the falls of rain at these stations.

Assistant Surgeon Balfour, in his notes on this subject, has well remarked "that the observations of scientific men support the belief that a mutual reaction goes on between these two physical agents and that the presence of trees greatly adds to the supply of water and feeds the running streams." The instance of a single district losing its supply of water on being cleared of forest, and regaining it again when restored to its original state, would not alone establish more than strong presumption that the clearing of the forest and the loss of rain followed each other as cause and effect; but the Honorable Court of Directors, in their circular, mention that this is not uncommon in America.

On the subject of springs, Assistant Surgeon Balfour quotes from Jameson's Edinburgh Philosophical Journal, a very remarkable instance at Popayan in Peru, of a district losing its supply of water from the clearance of the forest. Two instances corroborative of the

above have come under my own observation, and happened to friends in different parts of the country engaged in coffee planting. The first happened in a range of hills south-east of Bangalore, at a coffee plantation now called Glenmore in the Debenaicottah talook of the Salem district. The proprietor when preparing ground for a coffee garden which was watered by an excellent spring, was warned by the natives not to clear away the trees in the immediate neighbourhood of his spring,—he disregarded their warning, cut down the trees and lost his stream of water. The other instance happened at the village of Hoolhully about eight miles distant from the head of the new ghaut in Mungerabad, I wrote to the gentleman to whom it occurred, who answered as follows: "The cutting down trees and clearing jungle on the sides of ravines in the close vicinity of springs, undoubtedly has a great effect in diminishing the quantity of water. I found it so in one or two instances in ravines I have cleared for planting—at one place where I had a nursery, which I used to water by turning a water course from the spring, I found that since I cleared up the sides of the ravine in which the spring is (for planting), I have not any thing like the quantity of water I had before the shade was cleared. I presume this is to be accounted for by the increased action of air and sun,—at any rate, the natives about here are of that opinion. I leave the cause, however, to be settled by more scientific men than myself,—that the effect is so, there is no doubt. A ravine close to the bungalow where there is a spring, a few years ago I cleared for planting, and found the water decrease in like manner; but the coffee trees dying away, and the place being too small for a plantation, I did not renew them, but allowed the jungle to grow up again, since which the stream has nearly regained its former size."

The superintendent of Nuggur writes "that springs of water shaded by trees almost invariably dry up, on the trees being cleared away. This has been observed on the Neilgherry hills and many other woody districts." In what way trees influence springs it is impossible to say; that they do so, seems to be established, as also that they condense and attract vapour.

I cannot omit inserting at length the quotation from White's History of Selborne, part of which is alluded to by Mr. Balfour. "In heavy fogs, on elevated situations especially, trees are perfect alembics; and no one that has not attended to such matters, can imagine

how much water one tree will distil in a night's time, by condensing the vapour, which trickles down the twigs and boughs, so as to make the ground below quite in a float. In Newton Lane, in October, 1675, on a misty day, a particular oak in leaf dropped so fast, that the cart way stood in puddles and the ruts ran with water, though the ground in general was dusty. In some of our smaller islands in the West Indies, if I mistake not, there are no springs or rivers, but the people are supplied with that necessary element, water, merely by the dripping of some large tall trees, which standing in the bosom of a mountain, keep their heads constantly enveloped with fogs and clouds, from which they dispense their kindly, never ceasing moisture; and so render those districts habitable by condensation alone. Trees in leaf have such a vast proportion more of surface than those that are naked, that in theory, their condensation should greatly exceed those that are stripped of their leaves, but as the former imbibe also a great quantity of moisture, it is difficult to say which drip most; but this I know, that deciduous trees that are entwined with much ivy, seem to distil the greatest quantity. Ivy leaves are smooth, and thick, and cold, and therefore condense very fast; and besides ever-greens imbibe very little. These facts may furnish the intelligent with hints concerning what sorts of trees they should plant round small ponds that they would wish to be perennial, and show them how advantageous some trees are in preference to others. Trees perspire profusely, condense largely, and check evaporation so much, that woods are always moist; no wonder, therefore, that they contribute much to pools and streams. That trees are great promoters of lakes and rivers, appears from a well known fact in North America; for since the woods and forests have been grubbed and cleared, all bodies of water are much diminished; so that some streams, that were very considerable a century ago, will not now drive a common mill. Besides most wood-lands, forests, and chases, with us, abound with pools and morasses, no doubt for the reason given above. Again, Dr. Hales in his vegetable statics, advances from experience, that the moister the earth is, the more dew falls on it in a night; and more than a double quantity of dew falls on a surface of water, than there does on an equal surface of moist earth. Hence we see that water, by its coolness, is enabled to assimilate to itself a larger quantity of moisture nightly by condensation,

and that the air when loaded with fogs and vapours and even with copious dews, can alone advance a considerable and never failing resource. Persons that are much abroad and travel early and late, such as shepherds, fishermen, &c. can tell what prodigious fogs prevail in the night on elevated downs, even in the hottest parts of summer, and how much the surfaces of things are drenched by those swimming vapours, though, to the senses, all the while, little moisture seems to fall."

In Coorg and the hill country, it is impossible to move off the road when walking early and before the sun has dried the ground, the dews are so heavy, and the dripping from the trees so wetting, yet the roads are perfectly dry. Some crops in India, as the cooltie, depend entirely on the fogs for sufficient moisture to mature a crop.

In paras. 31 and 32 of General Cullen's report, he says, "In the forests of this coast and above the ghauts in the western parts of Mysore, Wynaad and Coorg, the trees are I believe every where nearly destitute of leaves, during the early part of the year, the driest and the hottest season, so that even in forest tracts, the earth is at that period exposed to nearly the full force of the sun's rays."

"The long grass and low jungle is also generally burnt down in these months, and the general heat and dryness in passing through such tracts are frequently intolerable. The almost entire absence of moisture and springs in forest tracts in the dry season is well known."

And at para. 34 he says, "The forests in this quarter therefore, whatever beneficial effects they may have during the rains or cooler portions of the year, would seem to exercise but little influence on the general climate, or in the preservation of moisture, at the very season when it is most required." General Cullen's recollection of these tracts is not in accordance with my experience of them. I was in the north of Coorg in December last and in Munzerabad in January of this year, and in January, 1847, it is true that the grass is generally fired, but very few of the trees are deciduous and even at that dry season of the year most of the deciduous trees were in full blossom, and preparing to throw out their spring crop of leaves. It is in the hottest season of the year, March and April, that the mangoe throws out its blossoms and young leaves, maturing its fruit in June; from what source does it derive the requisite moisture, to carry on the process of maturing its crop? In the months I

have mentioned, and in the districts in question, it was impossible to move off the roads till the sun had dried up the dew with which the grass and brushwood in the jungles was daily saturated. On the Baba Booden hills in April, 1848, the hottest season of the year, I found the fog so dense till 8, or 9 A. M. and the condensation of water on the trees in the jungles so great, that I used to be wet through in moving through them.

About 37 miles north of Bangalore is the range of hills of which Nundydroog forms the most conspicuous object; some friends encamped at the foot of these hills, were at a loss to account for the circumstance that Nundydroog was often clear of vapour, when two other hills close to it were covered with a cloud, nor were they able to account for it, till on ascending these hills, they were found to be covered with a stunted vegetation, from which Nundydroog was free. When encamped on Nundydroog, I observed rain frequently fall on those opposite hills, apparently avoiding the one on which I was. Doctor Darwin supposes that as the summits of mountains are much colder than the plains in their vicinity, they condense the vapours more readily, and so contribute to form springs; supposing Dr. Darwin's theory to be true, which I have no doubt it is, the condensation produced by the cold top of Nundydroog actually higher than the neighbouring hills, was more than counterbalanced by the circumstance of the others being clothed with verdure. The presence of springs near the top of insulated granite hills as Nundydroog, Sivagunga, Severndroog, and in fact on most of the insulated hills in Mysore, is not easily accounted for. These hills are insulated and rise out of the plain from 15 to 1800 feet, the base surrounded with blocks of granite. It is difficult to suppose that the causes we have been enumerating as influencing springs, can have any perceptible effect on those which are found under the lower strata, in Bangalore as deep as 50 feet,—for the sources which supply these, we must look to other causes.

I have the honor to be, &c.

BANGALORE,
23*d June*, 1849.

(Signed) C. I. SMITH, Surgeon,
Mysore Commission.

(True copy.)

M. CUBBON,
Commissioner.

Abstract of the monthly fall of Rain at Bangalore, from the year 1837 *to* 1848.

Months.	1837.		1838.		1839.		1840.		1841.		1842.		1843.		1844.		1845.		1846.		1847.		1848.	
	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.
January,.....	.....	..	.....	..	·55	3	. ....	..	.....	.....	.....	3	1·75	3	.....	1	2·95	3	.....	..	.....	..	. . .	..
February,.....	.....	..	.....	..	.....	..	.....	..	.....	.....	.....	..	.....	..	·35	2	.....	..	·15	1	1·60	4	....	..
March,.....	$\frac{5}{16}$	1	·45	1	·10	2	·20	2	1 slight	shower	.....	1	1·60	6	·70	2	·45	4	.....	..	.....	1	.....	..
April,.....	$1\frac{5}{16}$	2	·75	8	·85	4	·80	6	1·90	3	·6	4	.....	..	·15	5	2·75	8	·5	1	·85	5	2·65	8
May,.....	$5\frac{3}{16}$	13	2·70	8	6·95	9	7·65	13	2·95	10	2·20	9	8·0	8	4·5	9	1·95	8	8·40	11	3·75	15	7·92	10
June,.....	$3\frac{13}{16}$	13	1·85	7	3·75	8	2·40	8	1·90	10	8·25	10	3·45	10	1·40	7	7·30	12	1·85	12	1·20	8	1·70	12
July,.....	$4\frac{4}{16}$	14	drizzle	9	4·80	21	3·60	10	2·65	10	1·25	4	1·80	4	3·10	9	2·5	4	4·50	17	11·35	19	5·16	16
August,.....	$6\frac{9}{16}$	18	4·5	10	7·20	19	5·35	7	10·35	18	2·61	12	1·30	8	3·55	13	1·80	8	3·10	20	4·5	15	7·25	19
September,.....	$1\frac{14}{16}$	7	3·40	8	4·10	14	5·40	10	8·90	16	10·50	15	6·15	11	6·70	9	9·5	10	7·0	12	3·50	3	11.50	13
October,.....	$10\frac{8}{16}$	13	1·15	6	3·85	9	4·50	12	8·0	16	5·40	6	7·10	16	3·45	6	2·80	3	10·75	13	9·30	14	2·15	4
November,.....	$10\frac{7}{16}$	15	1·10	5	.....	3	·30	5	1·30	4	·45	3	.....	..	.....	..	·30	2	2·90	4	1·55	7	1·40	4
December,.....	$1\frac{9}{16}$	2	.....	1	·15	1	.....	..	.....	.....	.....	..	5·45	7	4·45	10	·50	2	·75	2	·85	3	·50	4
	$45\frac{9}{16}$	98	15·45	63	29·30	93	30·20	78	38·5	87	30·72	67	38·60	73	27·90	73	31·90	62	39·45	93	37	94	40·3	90

Register kept in the Cantonment of Bangalore.

Abstract of the monthly fall of Rain in the Nuggur Division, from the year 1837 *to* 1848.

Months.	1837.		1838.		1839.		1840.		1841.		1842.		1843.		1844.		1845.		1846.		1847.		1848.	
	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.
January,	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	·15	1	.....	..	.....	..	.....	..
February,	.....	1	.....	1	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	·51	3	·70	2	3·80	6	.....	..
March,	.....	7	....	2	.....	..	.....	2	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	·35	2	.....	..
April,	$1\frac{5}{8}$	2	$2\frac{1}{4}$	6	$3\frac{3}{5}$	5	$1\frac{1}{4}$	10	.....	7	$\frac{1}{8}$	1	$3\frac{1}{4}$	7	·15	1	3·50	6	·10	1	3·35	4	3·40	9
May,	$3\frac{7}{16}$	7	$1\frac{3}{8}$	8	$3\frac{7}{16}$	8	$2\frac{4}{8}$	4	$3\frac{5}{16}$	4	$2\frac{1}{4}$	2	.....	..	2·10	5	·20	1	1·70	5	7·15	9	5·75	16
June,	$1\frac{1}{2}$	8	$1\frac{3}{16}$	11	$1\frac{1}{16}$	9	$5\frac{9}{16}$	8	$2\frac{9}{16}$	3	$6\frac{5}{16}$	9	.....	..	4·64	15	5·15	16	5·35	15	1·55	5	2·65	10
July,	$2\frac{7}{16}$	12	$2\frac{1}{4}$	11	$7\frac{1}{4}$	24	$9\frac{6}{16}$	15	$3\frac{7}{16}$	6	$7\frac{9}{16}$	17	1·65	16	6·41	24	5·10	8	8·48	20	1·75	8	5·5	12
August,	$3\frac{7}{16}$	17	$2\frac{5}{16}$	13	$4\frac{3}{16}$	17	$\frac{13}{16}$	4	$3\frac{7}{16}$	9	$3\frac{13}{16}$	7	·51	4	4·4	16	2·50	14	4·60	19	·85	7	8·15	13
September,	$6\frac{1}{8}$	13	$2\frac{1}{8}$	10	$3\frac{1}{16}$	7	$\frac{1}{16}$	2	$\frac{13}{16}$	6	$8\frac{1}{16}$	10	4·50	11	5·55	8	5·65	10	1·55	9	·80	4	1·70	9
October,	5	11	$1\frac{3}{8}$	5	$5\frac{1}{16}$	7	$3\frac{10}{16}$	7	$10\frac{3}{16}$	14	.....	..	5·45	9	5·35	9	·30	3	8·50	12	8·30	15	2·40	7
November,	$8\frac{1}{2}$	15	$1\frac{1}{16}$	7	$1\frac{1}{8}$	1	.....	..	$1\frac{1}{16}$	1	.....	..	.....	..	.....	..	2·0	2	1·5	1	3·5	4	·75	3
December,	$1\frac{9}{16}$	1	.....	..	.....	3	.....	..	.....	..	.....	..	.....	..	2·0	6	·90	2	·20	1	.....	..	.....	..
	$32\frac{1}{16}$	94	$15\frac{11}{16}$	74	$29\frac{11}{16}$	81	$23\frac{1}{16}$	52	$24\frac{11}{16}$	50	290	47	15·36	46	30·64	84	25·96	66	32·3	85	30·95	64	29·85	79

Register kept at the Town of Shemogah, except during the five months when the Cutcherry is on Jummabundy.

Abstract of the monthly fall of Rain in the Chittledroog Division, from the year 1837 *to* 1848.

Months.	1837.		1838.		1839.		1840.		1841.		1842.		1843.		1844.		1845.		1846.		1847.		1848.	
	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.
January,	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	·40	1	.....	..	.....	..	.....	..
February,	.....	..	.....	..	.....	1	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	.....	..	3·50	5	.....	..
March,	.....	..	.....	..	1	1	.....	..	·62	1	·45	1	.....	..	.....	..	·30	2	.....	..	.....	..	.....	..
April,	.....	1	$1\frac{7}{16}$	4	$3\frac{1}{16}$	3	$2\frac{1}{16}$	1	1·12	3	·80	2	·95	4	1·30	4	1·10	3	·20	2	2·15	3	1·95	4
May,	$4\frac{1}{16}$	7	$1\frac{7}{16}$	3	$3\frac{7}{16}$	6	$1\frac{1}{16}$	5	2·70	3	3·55	7	8·30	9	4·30	8	4·0	7	8·30	7	5·95	6	7·5	7
June,	$1\frac{9}{16}$	1	$1\frac{}{16}$	1	$4\frac{7}{16}$	9	$2\frac{1}{16}$	6	3·55	9	4·65	6	2·80	3	3·85	10	5·40	11	4·0	7	·40	1	·85	3
July,	$2\frac{5}{16}$	5	$\frac{5}{16}$	2	20	7	$\frac{}{16}$	3	·65	2	2·55	8	1·45	2	3·75	9	·25	1	10·20	9	5·55	6	1·25	5
August,	$3\frac{}{16}$	10	$2\frac{9}{16}$	8	$5\frac{5}{16}$	13	$1\frac{}{16}$	5	4·35	11	3·10	7	2·20	4	1·5	3	·55	1	1·55	5	1·50	4	·65	1
September,	$1\frac{}{16}$	5	$4\frac{5}{16}$	6	$8\frac{}{16}$	11	$7\frac{}{16}$	8	7·15	8	8·65	12	6·55	9	3·20	6	13·20	7	6·55	4	1·85	1	2·25	6
October,	$4\frac{}{16}$	5	$2\frac{}{16}$	3	$3\frac{}{16}$	6	$5\frac{}{16}$	9	8·60	17	3·55	3	18·10	17	5·40	5	·95	1	23·70	9	9·45	14	1·45	2
November,	$9\frac{}{16}$	11	$\frac{}{16}$	1	$\frac{}{16}$	3	$\frac{1}{16}$	1	·40	2	.....	..	.....	..	.....	..	·25	1	1·45	2	1·35	2	1·50	1
December,	.....	..	.....	..	$\frac{}{16}$	1	.....	..	.....	..	.....	..	1·75	4	2·50	5	.....	..	·90	1	.....	..	.....	..
	$26\frac{10}{16}$	45	$12\frac{1}{16}$	28	$32\frac{9}{16}$	61	$21\frac{11}{16}$	37	29·14	56	27·30	46	42·10	52	25·35	50	26·40	35	56·95	46	31·70	42	16·95	29

Register kept *chiefly* at the Town of Toomcoor the Southern part of the District.

Abstract of the monthly fall of Rain in the Astagram Division, from the year 1837 *to* 1848.

Month.	1837.		1838.		1839.		1840.		1841.		1842.		1843.		1844.		1845.		1846.		1847.		1848.	
	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gange.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.	Rain Gauge.	No. of days in each Month.
January,	.....	..	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	·10	1	1·3	3	.....	...	.....	...	.....	...
February,	.....	..	.....	...	.....	...	.....	...	.....	...	1·25	2	.....	...	·15	1	·15	1	.....	...	·30	1	.....	...
March,	$\frac{1}{16}$	3	$2\frac{2}{8}$	2	.....	3	.....	...	.....	...	.....	...	.....	...	.....	...	3·10	3	.....	...	·15	1	.....	...
April,	$\frac{1}{16}$	4	$3\frac{3}{8}$	5	.....	5	.....	...	$1\frac{1}{8}$	3	·37	1	.....	8	2·65	4	7·20	11	1·35	2	1·85	4	4·70	6
May,	$3\frac{1}{16}$	9	.....	11	.....	9	$3\frac{3}{8}$	11	$4\frac{1}{16}$	7	2·90	8	2·25	8	9·35	11	10·75	9	4·35	8	5·90	10	4·55	8
June,	$2\frac{1}{16}$	5	$\frac{1}{16}$	1	.....	5	$2\frac{1}{8}$	5	2	2	$4\frac{1}{8}$	8	3·95	6	5·50	7	1·40	6	·25	9	·75	3	·45	2
July,	$\frac{1}{16}$	4	$\frac{2}{16}$	3	$\frac{1}{16}$	18	$1\frac{4}{8}$	9	$\frac{4}{16}$	3	$\frac{12}{16}$	5	·90	3	2·90	7	·25	2	4·95	9	1·90	8	1·0	3
August,	3	5	$\frac{1}{8}$	6	$1\frac{6}{8}$	10	$\frac{6}{8}$	3	$3\frac{1}{2}$	6	$3\frac{1}{2}$	9	2·0	5	1·35	5	·75	4	2·70	7	·45	2	2·55	6
September,	$3\frac{9}{16}$	8	$7\frac{5}{16}$	12	$3\frac{2}{8}$	11	$\frac{5}{16}$	2	$11\frac{7}{8}$	8	$3\frac{1}{2}$	7	3·40	9	4·30	7	4·50	11	1·15	4	·55	3	8·25	16
October,	$5\frac{2}{16}$	10	$3\frac{1}{2}$	6	$5\frac{1}{16}$	11	$5\frac{1}{16}$	9	$7\frac{3}{8}$	10	$7\frac{1}{2}$	6	8·95	11	1·95	3	4·70	7	11·10	13	10·5	16	3·20	7
November,	$6\frac{1}{16}$	7	$1\frac{13}{16}$	4	$\frac{9}{16}$	4	$2\frac{7}{16}$	3	$2\frac{1}{8}$	3	.....	...	.....	...	·40	1	·40	1	1·55	3	1·50	8	2·20	7
December,	.....	..	$\frac{2}{8}$	1	.....	...	.....	...	.....	...	.....	...	1·10	2	5·80	6	.....	...	·5	1	1·45	4	.....	..
	$25\frac{9}{16}$	55	$19\frac{11}{16}$	51	$9\frac{11}{16}$	76	$15\frac{7}{16}$	42	$31\frac{7}{8}$	42	23·89	46	22·55	52	34·45	53	34·20	58	27·45	56	24·85	60	26·90	55

Register kept at the Town of Mysore, unless when the Cutcherry is on Jummabundy.

(True copy.)
M. CUBBON, *Commissioner.*

(Signed) C. I. SMITH, *Surgeon.*